REPORT OF THE 1988 AERIAL STUDIES OF THE WEST INDIAN MANATEE (*Trichechus manatus*) ON THE WEST COAST OF FLORIDA

Technical Report: #228

Submitted to:

Natural Resources Department
County of Sarasota
P.O. Box 8
Sarasota, Florida 34230

Submitted by:

Jessica J. Kadel
Angela K. Dukeman
Geoffrey W. Patton
Mote Marine Laboratory
1600 Thompson Parkway
Sarasota, Florida 34236

October 18, 1991

Suggest reference Kadel JJ, Dukeman AK, Patton GW. 1991. Report of the 1988 aerial studies of the West Indian Manatee (*Trichechus manatus*) on the west coast of Florida. County of Sarasota. Mote Marine Laboratory Technical Report no 228. 55 p. Available from: Mote Marine Laboratory Library.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION AND PROBLEM STATEMENT

The West Indian Manatee, Trichechus manatus, is an endangered species which is protected by federal, Florida state, and even some local legislation. In spite of this protection, it is still in jeopardy throughout its entire range due to a low reproductive rate, loss of habitat, and high mortality, the later two of which can be partially associated with human activity.

This report presents the 1988 sighting data for manatees from Anna Maria Sound to northern Charlotte Harbor, including the Myakka River. This work is a continuation of manatee population studies conducted by Mote Marine Laboratory since 1985. The project objectives are to determine the distribution and habitat requirements for manatees using the bays between Anna Maria Sound and northern Charlotte Harbor. Specific goals are outlined as follows:

Year 1. Identify if preferred areas exist.

Years 2-5. Determine variability in preferred-site usage.

Years 6-10. Monitor variability and identify habitat preference determinants.

This report represents Year 4 in the second phase.

II. LITERATURE REVIEW

A. Natural History - Taxonomy

The West Indian Manatees are marine mammals part of the modern order Sirenia. Four species, including both manatees and dugongs, are listed under Sirenia though a fifth species, Hydrodamalis stelleri, or the Stellar sea cow, was hunted to extinction in the Bering Straits in the 1700's, twenty-seven years after its discovery (Stejneger, 1886). The dugong is found in the Indo-Pacific

region and varies from manatees in that its tail is similar to that of a whale, being forked instead of round and flat. The manatees belong to the genus Trichechus of which one species is found on the west coast of Africa, one in the freshwater of the Amazon River, and the other species is distributed throughout the tropical and subtropical waters of the Caribbean and Florida (Hartman, 1976).

Recent studies have shown that T. manatus latirostris, the Florida manatee, is a distinct subspecies from those of the subspecies T. manatus located in the Caribbean. These findings have been concluded from skull morphometrics. The deep water barrier of the Straits of Florida have kept Florida manatees genetically isolated from their Caribbean counterparts (Domning and Hayek, 1986).

B. Description

Manatees are gentle, walrus shaped mammals with a flat, rounded tail. Adults usually range from 2.5-4.5 meters (14 feet) in length and weigh from 200-1500 kg (440-3300 pounds), though females tend to be heavier (Hartman, 1968, 1971; Jones and .Johnson, 1967; Quiring and Harlan, 1953; and Gunter, 1941). The adults also range in color from grey to brown, while calves tend to be darker at birth and lighten in color after one month. No dimorphism has been documented, though Hartman (1979) describes females as "bulkier" than males of similar size. The female can be readily identified by the location of the genital slit, which is just anterior to the anus. The male genital slit is closer to the umbilicus (Moore, 1951a).

The skin of the manatee is thick with fine wrinkles. The outer surface of brackish or salt water inhabitants may be covered with algae or barnacles which could be an explanation for the continual sloughing of the epidermis (Hartman, 1969). Scar patterns are often visible, as they may remain white in

contrast to the darker pigmented skin. Below the skin there are two thin layers of blubber used for insulation. The sparse distribution of hair which covers the body is thought to aid in detecting water currents. The skeleton consists of thick, heavy bones which function in buoyancy control (Brown, 1878 and Hartman, 1976).

The face is covered with stiff whiskers and is usually described as "bulbous." The whiskers help the muscular upper lip to manipulate food into its mouth. The molars, which are used to grind their food, are formed in the back of the jaw. They slowly move forward, wear down, and eventually fall out when they reach the front resulting in continual replacement. This may be an adaption to the consumption of abrasive food which is usually mixed with silt and sand (Walker, 1968).

The nostrils are located on the dorso-anterior surface of the snout. They are tightly closed by valves when the animal is submerged and open only when the nose is above water and the animal is actively breathing. The ear openings are small and located behind the eyes. Despite the size of the ear, however, manatees hear quite well, as well as seeing, both above and below the water.

C. Distribution

The West Indian manatee is currently found from the southern United States through the Caribbean Islands, eastern Central America, Colombia, Venezuela, and southward to Brazil's northeast coast, as well as in all major island systems of the West Indies. Within the U.S., their range is largely confined to the peninsular Florida and Georgia coasts. However, wandering manatees have been sighted as far north as the Potomac River in Virginia, and as far west as the

Rio Grande River (Rathbun et al., 1982). The rare animal found west of the Mississippi is thought to have followed the coast north from Mexican waters.

Manatees that roam beyond Florida in summer and fail to return by winter rarely survive. The West Indian manatee is basically a tropical mammal inhabiting temperate waters and is at risk from winter cold spells. The historical winter range of manatees is thought to be centered in southern Florida, with a few refuges in northern Florida. Over the past thirty years, the construction of power plants and industrial sites has extended the manatees' winter range to include both man-made and natural warm water refuges.

Hartman (1974) estimated a statewide manatee population of 750 to 850 animals, with 1000 being the conceivable maximum, based on limited aerial surveys" and interviews with observers. A subsequent attempt (Irvine and Campbell, 1978) to survey the entire state sighted 738 manatees. A total of 853 animals identified by scar patterns is included in the 1985 Manatee Identification Catalog compiled by the U.S. Fisheries and Wildlife Service. The "official" minimum population estimate for 1987-1988, according to the Florida Department of Natural Resources, is 1200 animals with equal numbers residing on both coasts (Weigle, 1987). This figure is based on a winter aerial survey of power plants and counts in natural warm water refuges, plus estimates for areas that were not surveyed.

It can be shown by aerial survey data that manatee distribution is dependent upon water temperatures and their range is determined by the seasonally cold waters (Hartman, 1974, 1979; Husar, 1977). When ambient water temperatures drop below 20° C, manatees usually move to a warm water source such as springs or power plant effluent. Man-made wintering sites have extended the manatees' range. The animals apparently leave these warm water refuges quite often to look

for food, but this only occurs during breaks in the cold spell and then only at the warmest hours of the day. This movement increases their chance of suffering from cold related shock (Packard, 1981). Most of the winter aggregations center around twenty-four warm water sources; six of which are natural, while the rest are man-made (Hartman, 1974). Important winter sites on the west coast of Florida include the Homosassa and Crystal Rivers, the Bartow Power Plant (Florida Power Corporation), Big Bend Generating Plant (Tampa Electric Company), and the Fort Myers Power Plant (Florida Power and Light Company).

Apparently not all manatees take shelter in the warm water refuges and their activity is not known. It is thought, however, that they may move to offshore waters, to the center of large bays, or to rivers, where temperature differences would not be as extreme (Hartman, 1974).

Thus, it is evident that the population size of manatees is not accurately known, and certainly trends cannot be deduced from current data. Furthermore, manatees are long-lived and have low reproductive rates causing difficulty is identifying trends. Continued and intensified studies are needed in order to assess the status of manatees in Florida (Morgan and Patton, 1990).

D. Habitat

Trichechus manatus can inhabit fresh, brackish, and even salt water. They are usually found in rivers, estuaries, and bays. They move freely throughout these types of environments, and tend to avoid shallows less than a meter in depth. They generally prefer water that is up to 5 meters (16 feet) deep and rarely are found any deeper. The following four factors, as described by Applied Biology, Incorporated (1977), are thought to be determining factors as to why manatees are located in specific sites:

1) availability of vascular aquatic vegetation (especially Thallasia)

2) warm water winter refuges

3) proximity to deep water channels

4) a source of fresh water

It appears that water turbidity has little or no effect on the animals which reside in clear as well as very muddy waters (Husar, 1977; Hartman, 1979), but there is a possibility that "shelter" may be a determining factor. Those parameters that may constitute "shelter" for manatees are yet to be determined.

E. Feeding

Hartman (1971) states that manatees feed from six to eight hours a day in one to two hour sessions. They are herbivorous animals, usually feeding on submerged, floating, and emergent plants. Protein supplement is provided by inadvertent consumption of epiphytes associated with the seagrass or occasional consumption of algae or small invertebrates if the preferred food is not available (Hartman, 1971).

The animals use their flippers to help guide food toward their muscular mouth -where the vegetation is ground by their molars. When feeding, chewing is only interrupted by breathing that occurs every one to five minutes. The average chewing rate is two chews per second. As the animal becomes sated, it slows its feeding activity until eventually it stops altogether, after which it moves from the area.

It has been observed that manatees have preferential feeding areas, due to the fact that they have been seen returning to the same sites to feed over long periods of observation (Hartman, 1979).

Finally, manatees have been observed drinking fresh water from a hose and from storm drains (Phillips, 1964). It is unknown whether fresh water drinking is a requirement for good health or not.

F. Reproduction

Because manatees are generally solitary animals, it is unusual to see them in groups unless they are in a mating herd. The groups, comprised of one female (cow) and several males (bulls), may remain together for the entire time the female is in estrous, sometimes up to a month. The cow evades all of the bulls' attempts to copulate until she is receptive. When she does, the cow promiscuously mates with several males. The two mating animals copulate in a ventral-to-ventral position holding on to each other with their front flippers (Hartman, 1971, 1979). Mating usually occurs in water less than one meter deep.

There is no specific breeding season for manatees, therefore calves may be born at any time of the year. Females have one calf every three to five years. Cows occasionally seen with two calves may have bore twins or may have adopted an orphan. The manatees' gestation period is probably 385-400 days (13 months) (Moore, 1951a). Newborn calves are one meter long at birth and weigh about 30 kilograms (66 pounds; Odell, 1982).

Upon the birth of the calf, the mother assists it to the surface and then lowers it, establishing a steady rhythm and breathing pattern. At first the calf uses only its flippers for swimming, but eventually they learn to use their tails (Barbour, 1937; Moore, 1957). Suckling occurs underwater and calves remain dependent on their mothers for two years or longer. The bond between mother and calf extends beyond weaning to enhance survival rates by allowing the

calf to learn feeding locations, winter refuges, and migratory routes (O'Shea and Shane, 1985).

G. Social Interactions

Manatees do not exhibit territorial behavior and are mildly social. The groups tend to casually form and disperse during which time no form of hierarchy is established. "Kissing" or muzzle-to-muzzle contact is thought to be a form of mutual identification (Moore, 1956). They also mouth, muzzle, nudge, and embrace others (Hartman, 1971). Play occurs only when the animals are rested, fed, and free from environmental pressures including human harassment. Moore (1956) observed that even in extremely crowded conditions the animals do not exhibit irritability.

H. Mortality Factors

In 1974, a manatee carcass salvage program was initiated by the U.S. Fish and Wildlife Service to document causes of manatee deaths in Florida. The objectives for the program include collecting biological information from the carcasses, determining cause of death, noting seasonal and geographic trends in the data, and summarizing cause of death data. The Florida Department of Natural Resources (FDNR) took over the responsibility in 1985 and publishes monthly and yearly summaries of mortality data. Cause of death categories are based on probable circumstances at death (Bonde, O'Shea and Beck, 1983). The USFWS and FDNR have developed seven categories (to be modified somewhat in 1990):

Boat/Barge Collision: Deaths attributed to collisions with boats or barges exhibited through massive trauma (gashes, cuts, internal damage) or resulting in a blow causing unconsciousness and subsequent drowning.

Crushed/Drowned in Floodsate or Canal Lock: Death resulting from entrapment in gates of navigation locks or flood control dams.

Other Human Related: Miscellaneous human-caused mortalities including animals shot by vandals, poaching, entanglement (fishing nets, crab trap lines, etc.), ingestion of or infection from monofilament fishing line and hooks, and so on.

Perinatal (<50 cm): Deaths as a result of separation from the mother; stillbirths and neonates, young deceased animals of undetermined causes. If a positive cause of death can be determined, the calf is tallied in that category.

Other Natural: Deaths involving disease, starvation, cold induced mortalities, or reproductive complications.

Undetermined: Cause of death cannot be determined from the necropsy often due to extreme decomposition.

Verified, Not Recovered: Reports of dead manatees that were verified but not recovered by the necropsy team.

There are also human related factors which could contribute to cause of death. These include pollution, loss of habitat, and harassment which may discourage manatees from utilizing their preferred areas.

I. Legal Status

In the late 1700's the English established Florida as a manatee sanctuary. It was at that time that settlers first became aware of the importance of manatees. Despite this concern, numbers continued to decline and their extinction was predicted in the late 1800's (Campbell and Powell, 1976). As a result, a Florida law was enacted to protect the manatees and later, in 1907, a Florida statute (Ch. 370.12) was passed imposing a $500 fine and/or a six month prison sentence on anyone caught molesting or killing a manatee.

In 1969, the manatee was listed as an endangered species by the Department of the Interior under the Federal Endangered Species Conservation Act. This protection was reaffirmed in the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. This legislation imposed up to a $20,000 fine

and/or a one year prison sentence upon anyone who knowingly attempted to "harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect endangered species." The U.S. Fish and Wildlife Service in cooperation with state agencies is responsible for administering the law.

III. STUDY DESIGN

A. Field Methods

Figure 1 illustrates the aerial survey location on the west coast of Florida, showing the boundaries of the northern and southern regions,, Flight parameters are itemized in Table 1. Each survey is designated by a letter and consists of one northern and one southern flight.

Flights were conducted at 80-90 knots at an altitude of 150 meters (500 feet), using either a Cessna 172 or Cessna 150 high wing aircraft. Bays were surveyed starting at the north end of the survey area and flown south. The Gulf beaches and the Myakka River were surveyed from south to north. Flights were postponed if: 1) wind speed or gusts exceeded 15 mph; 2) Visual Flight Rules (VFR) were not in effect; 3) severe weather was forecast or encountered for the observation period; or 4) sighting conditions (combined water clarity and surface conditions) were too adverse.

A primary observer (with at least 25 hours of aerial survey experience) occupied the right front seat. Polarized sunglasses were used to improve visibility through the water. Secondary observers occasionally occupied the rear seats. All manatee sightings were logged, with appropriate notations if the primary observer did not make the initial sighting. Photographic records

were made of any animals with scar patters that might be recognizable in the future (these data are not covered in this report).

Once sighted, herds, defined as one or more animals, were circled until all data to be recorded could be verified. The location, number, life stage (adult or calf), and any identifiable behaviors were recorded on the standardized map sets. Manatee locations were indicated on the maps by a "Tm" with a dot (if the herd was stationary) or with a directional arrow (showing vector of movement). The number of animals (denoted as number of adults "+" number of calves; e.g., Tm 3+1) in the herd was recorded next to the "Tm", as was the initial time of the sighting and the numbers of any photos taken.

Additional data recorded for each page of the map set included: date of the survey, the beginning and end times, water clarity, surface conditions, number of adults, number of calves, and total number of manatees sighted. For the purpose of this study, calves were defined as one-half length (or less) of accompanying adults. Water clarity was estimated form the air for each sub-region according to the scheme in Table 2A.

Surface conditions were classified according to the Beaufort scale presented in Table 2B. Incidental sightings of sea turtles (Caretta) and bottlenose dolphins (Tursiops truncatus) were noted but are not discussed in this report.

Monthly water temperatures for the northern survey region were provided by the Manatee County Environmental Action Commission for northern Sarasota Bay at a site South of the Cortez Bridge. Monthly temperatures for the Myakka River in the southern survey region were supplied by the Environmental Quality Lab in Port Charlotte. The data used was collected at a station at the mouth of the Myakka River.

It is important to note that each survey represents a measurement of manatee abundance for that flight only. It is assumed that many of the same manatees are recounted on subsequent flights. The total number of manatees seen in 1988 is a summation of sightings recorded for each individual survey and does not represent an estimate of the total manatee population for the survey area.

Presumably, not all manatees are sighted on a survey due to less than optimal water clarity and surface conditions occurring in the area. However, consistent application of established and broadly-accepted methodology provides for comparison between surveys. Thus, what is presented is a relative measure of minimum manatee abundance.

B. Laboratory Methods

1. Sightings

For this report, the survey area was divided into twelve sectors (Figure 2) modified slightly from previous years. The northern region was comprised of sectors I-VII, and the southern region consisted of sectors VIII-XII. Manatee sighting locations are shown on maps of the survey area (Figure 3.a-g). Each sighting was designated by a flight letter and a herd size, (e,g. N3+1).

Seasonal and regional distribution and abundance throughout the survey area were shown in two manners. The first was an average of number of animals sighted in each month or each sector for each month. In order to correct for months with unequal numbers of surveys or incomplete surveys, monthly and regional indices were used. Originally described in Nabor and Patton (1989), these monthly or regional indices were based on the Total Survey Effort (T.S.E.) for each month or region. One T.S.E. unit was accumulated per "visit" to each sector and each survey within a month. The T.S.E. units were then summed for

each month (or sector) and used to divide the total number of manatees seen for all surveys in that month (or sector) to yield the appropriate index.

These indices were used to express seasonal and regional abundances of both calf and total sightings. The calf and total sightings were also shown as the average number of manatees in each sector by month. The calf data was then considered as percentage of total sightings by month and season for the northern, southern, and total survey area.

The maximum typical population for the survey area has previously been estimated by averaging the five highest survey counts (Method 1, Nabor and Patton, 1989). To adjust for variation in the number of surveys flown from year to year, Method 2 averages the highest counts from 25% of the number of surveys flown.

2. Herds

The percent of animals in each size herd were graphed to depict herd-size distributions. Since calves are vitally dependent on mothers, the mother-calf pairs were separated from the counts to identify the proportion of these pair bonds in herd sizes of greater than one. The value for this relationship was determined by assigning one adult from a herd as "mother" for each calf counted. The rare sightings with one adult and two calves were noted, but otherwise there was assumed to be no twining or fostering. The two groups were then graphed: "Mothers + Calves" and "Other Adults". The herd sizes of manatee sightings were also graphed as average herd size by month and by sector.

3. Movements

Manatee movement trends were examined through vector analysis of the number of occurrences recorded for manatees moving in a given compass direction. The set of observations for a given direction (in degrees) was plotted as a vector with the magnitude equal to the number of observations for that direction. A plot for each subsequent set of observations for a given direction was connected to the end point of the previous vector. The result was a net displacement from the origin. Theoretically, a random directional distribution would produce a net displacement proportionately small for the magnitudes of component vectors, (<1.0). In order to compare vector plots consisting of unequal numbers of directional sighting records, a directional "Factor" was calculated by dividing the net displacement by "X", which represents the average magnitude for all the vectors in which observations were made.

4. Mortality

Manatee mortality factors for 1983-1988 were provided by the Florida Marine Research Institute, St. Petersburg, Florida. These were graphed to identify numbers for categories of cause of death.

IV. RESULTS AND DISCUSSION

A. SIGHTINGS

1. Relative Abundance

Table 1 shows the data and manatee counts for the sightings recorded by the primary observer for each flight in 1988. Flight M surveyed only northern sectors while Flight P surveyed only southern sectors. Flight S surveyed only sectors I-V, due to severe weather. The cumulative number of sightings was 1280

animals in 21 surveys. The highest count of manatees, 113, was recorded during the second survey in October giving this month the highest monthly average of manatees, (100), and herds, (43). The fewest manatees were sighted in January (4), although only one herd was counted in February. The average number of manatees per survey for the year was 61 while the average number of herd sightings was 29. The typical maximum populations were determined to be 37.8 for the northern region, 75.4 for the southern and 102 for the entire survey area using the method described above. Calves comprised 12.4% of the total count. Both herds and calves are discussed in further detail in a separate section.

2. Instantaneous Distribution

Figures 3a-g show sighting locations of manatees. Many areas can be identified as places of regular and recurring use from both aerial sighting locations and public reports. In the Northern survey area, Bowles Creek in Sector III has not had many sightings, but due to the proximity to the Sarasota-Bradenton Airport, surveys are often interrupted by air traffic. However, the limited sightings coupled with citizen reports suggest it may be an important area.

Manatees were recorded for 18 of the 20 flights in Sector IV. Within Pansy Bayou, sightings from nine flights coupled with reports from area residents suggest it is especially important during most of the year. The lower part of Sector IV in the waters surrounding northern Siesta Key, sightings were recorded during 10 of the flights. Public reports also support heavy manatee usage of the entire area including the beach, Grand Canal, Phillippi Creek and the bridge areas.

In the southern area, Forked Creek and Lemon Bay (Sector VIII) appeared to be important areas with manatees sighted in all (16) but three surveys flown. Large numbers of manatees were recorded in Turtle Bay and the Myakka River (Sectors XI and XII) at all times of the year with the exception of January and February, when animals are absent from Turtle Bay but not the Myakka River. Also, no animals were sighted in the Myakka River in August. These findings support the data gathered from Mote Marine Laboratory's aerial surveys from 1985-1987 (Nabor and Patton, 1989).

3. Seasonal Distribution

The seasonal distribution of manatees in the study area is displayed in Figure 4, as the average number of animals seen per month. Overall survey sightings show a peak in September and October. There was a secondary peak beginning in April, and continuing through May, June, and July. In January and February, however, sightings were at a minimum. The low number of sightings in August in both northern and southern areas could be the result of poor sighting conditions during those surveys. Also, manatees disperse throughout the summer and may have moved to other areas during that month.

Figure 5 shows monthly averages for the number of animals in the northern and southern regions of the survey area. Relatively few animals were seen in either region during the winter. Sightings in the north increased in March and remained steady until they increase again in September, October, and November. The southern region shows a steady increase reaching a maximum in April. There is a slight decrease in values, but they remained fairly constant through October, with the exception of August, which showed unexpectedly low numbers.

The survey was aborted in November due to poor survey conditions. Also, as expected, the numbers diminished in December.

The monthly water temperatures in Figure 6 show similar patterns in both the northern and southern areas. Waters warmed in both regions in April and May, correlating with the increase in manatee abundance. Temperatures continued to increase until peaks in August and September. Following this increase, manatee abundances increased in September and October. The sharp temperature drop in October and again in November (North) and December (South) correlate to the decrease in manatees as they move to warm water refuges outside the study area. The slightly cooler Myakka River water temperatures in mid-summer are likely due to rainwater discharge.

The monthly index of manatee sightings (defined as total number of manatees sighted in a month per survey effort for that month) is shown in Figure 7. These findings show that manatees were most abundant in April and October, though they were present in all months. Similar to the graph of monthly averages, the index decreased slightly after April and remained fairly constant before it steadily increased to a second peak in October. After this the values dropped of rapidly.

4. Regional Distribution

Figures 8a-1 illustrate the average number of manatees sighted in each sector for each month. In January and February, no manatees were sighted except in Sector 12, the Myakka River. In March, the animals began to move to the northern region and by May they were dispersed among all sectors. The data supports the idea that movement occurred throughout the rest of the year in northern and southern regions until December, when few sightings were made.

The data shows that Anna Maria Sound (Sector I), Lemon Bay (Sector VII), Charlotte Harbor (Sector XI), and the Myakka River (Sector XII) have a higher abundance of manatees during the colder months than do other sectors. These areas continued to be areas with a relatively high abundance in the warmer months. The northern region of Sector IV (Lido Key and City Island) also exhibited a high abundance in the summer.

Figure 9 displays the regional index. This calculation depicts overall usage patterns for the entire survey area. This data corrected for unequal numbers of surveys also supports Sectors IV, VIII, XI, and XII as high usage areas.

B. CALVES

1. Relative Abundance

It is thought that manatees may be born at any time of the year and lack a specific breeding season (Hartman, 1979; Husar, 1977). Calves comprised 12.4% of the total number of manatees in 1988. In the northern region, 10.5% of the animals viewed were calves, while calves comprised 13.1% of the southern survey area.

The percentage of calves sighted in each month for the northern, southern, and overall survey area are shown in Figure 10. There appears to be two peaks indicating higher calf populations for the total area in April-July and again in October-December. In other months, however, calf sightings remained low. The trends for the two regions were similar with three exceptions. In March, the northern region showed no calf sightings and in May, the northern region contained very low percentages of calves. Since the southern survey was not flown in November, no data was obtained for that month. The highest percentage

of calves observed in the northern survey was during October while the highest percentage found in the southern region was shown as a double peak; one in April and one in June-July.

2. Seasonal Distribution

The seasonality of calf percentages is presented in Figure 11. The winter season consists of January, February, and March; spring: April, May, and June; summer: July, August, and September; and fall: October, November, and December. The overall area data shows that the highest percentage of calves are found in the spring, though percentages in the fall are only slightly lower. When the seasonal calf percentages are divided into the northern and southern survey regions, the northern region graph indicates there was a higher percentage of calves sighted in the fall and no sightings in the winter. The graph of the southern region calf percentages indicates that more calves were sighted in the spring. The fewest sightings were recorded in the winter, similar to the northern region. The data is inconclusive as to whether there is a specific calving period. It does support, however, that there are fewer calves seen in the winter. Therefore, winter is not a calving period for the study area.

3. Regional Distribution

The greatest percentage of calves found in any particular region was found in Sector XI (Charlotte Harbor), Sector II (southern Anna Maria Sound and Palma Sola Bay), Sector V, (Blackburn Bay) and Sector VIII (South Lemon Bay). It is thought that these areas may be functioning as nursery grounds.

C. HERDS

1. Relative Abundance

The 1988 data shows that 608 herds were sighted. The sizes of the herds ranged from 1-21 individuals. The average herd size was 2.1 animals, comparable to values in previous years (2.3 in 1985, 2.0 in 1986, and 2.2 in 1987). Of all the herds, 29.9% were found in the northern region while 70.1% were observed in the southern region. Only one herd of two animals (0.2% of the total animals) was spotted in the Gulf of Mexico. The Gulf sightings may be low due to the fact that only 500 feet of water nearest the beach was surveyed. The lack of vegetation and fresh water may also decrease the suitability of the Gulf habitat.

Figure 12 illustrates herd size distribution as percent of total herds for each size with the mother-calf pairs isolated from the other adults. Groups of four or fewer manatees accounted for 93.4% of the herd sightings and 74.9% of the individuals. Solitary manatees comprised 52.1% of the sightings. Individuals grouped in twos and threes comprised 34.9% of the herds, These results remain comparable to those reported in various studies (Hartman, 1979; Odell, 1979; Irvine, et al., 1981; Patton, 1980, 1986; and Patton, et al., 1987) for this and other areas.

2. Seasonal Distribution

Average herd sizes for each month are depicted in Figure 13. Above average herd sizes in February, March, and April may be a suggestion of migratory aggregations (particularly during February). The high average herd size in September and October may be evidence of fall breeding or migratory aggregations. It is not likely that the winter peak indicates a breeding

aggregation as it is shown earlier that it is unlikely that calving, which occurs approximately one year after mating, occurs in the winter months, unless the calving is occurring elsewhere, outside the study area.

3. Regional Distribution

The average herd size per sector is shown in Figure 14 and shows some variation on a regional basis. In the northern region larger herd sizes were found in Sectors V and VI. The southern region showed above average herd sizes in Sector XIII (Lemon Bay) and Sector XI (Turtle Bay).

D. MOVEMENTS

Directional movements were recorded for 16% of the manatee sightings. Vector analyses for the entire year are shown in Figure 15 while analysis for each season are depicted in Figures 16a-d. The factors for spring and summer were both greater than one, (2.1 and 1.6 respectively), indicating a strong movement. The net direction of movement in the spring season was West and in the summer was East-Southeast. The net directions during the other seasons were random as was the net for the year.

The westward displacement in the spring could be the result of northwesterly migration of manatees from southern wintering sites (Fort Myers) coupled with southwesterly migration from northern (Tampa Bay) sites. The summer movement pattern could represent local movements driven by some as yet unexplained need(s) such as freshwater or foraging forays.

E. MORTALITY

Recent manatee mortality data for Sarasota County are depicted in Figure 17. Since 1985, the manatee mortalities have increased each year. Of the identifiable causes of death, human activities have had a strong detrimental effect on manatees. Since the inception of the Manatee Carcass Salvage Program in 1972, Sarasota County had not registered a single manatee mortality attributable to boating activity. In 1987, Sarasota County had both its first and second manatee deaths from boat strikes. This level of boating related mortality is continued in 1988. Deaths from boat/barge collisions in 1987 represented 40% of all known deaths and 29% in 1988. The large categories of undetermined deaths (43%) and perinatal mortalities (29%), also increased from the previous year.

V. ACKNOWLEDGEMENTS

This study has been funded primarily by the West Coast Inland Navigation District comprised of Manatee, Sarasota, Charlotte, and Lee Counties. Sarasota County provided contract management. Thanks goes to these groups and all other individuals and organizations providing financial support. The monthly water temperature data from Manatee County Environmental Action Committee and the Environmental Quality Laboratory in Port Charlotte is also greatly appreciated. Acknowledgements also go to our pilots: Paul Graybill, Scott Sorenson, and Bud Freeman; primary observers: Jay Sprinkel, Peter Nabor, and Geoffrey Patton; secondary observers: Paul Default, Owen Smith, Tracy Beecher, and Karen Kipp; and those that helped prepare the report: Al Catalano, the summer intern who helped organize maps and raw data and Francesann Logan for assisting with the revisions to the manuscript.

VI. LITERATURE CITED

Applied Biology, Incorporated. 1977. Review of the ecology and life history of the Florida manatee. Prepared for Florida Power and Light Company, Miami, Florida. Atlanta, Georgia. 13pp.

Barbour, T. 1937. The birth of a manatee. Journal of Mammalogy. 18: 106-107.

Bonde, R.K., T.J. O'Shea and C.A. Beck. 1983. Manual of procedures for the salvage and necropsy of carcasses of the West Indian Manatee. Sirenia Project, U.S.F.W.S. Report. Gainsville, Florida. 173pp.

Brown, A. 1878. The Sirenia. American Naturalist. 12:291-298.

Domning, D.P. and L.C. Hayek. 1986. Interspecific and intraspecific morphological variation in manatees (Sirenia: *Trichechus)*, Marine Mammal Science. 2(2):87-144.

Gunter, G. 1942. Further miscellaneous notes on American manatees Journal of Mammalogy. 23(1):89-90.

Hartman, D. 1968b. Ecology and behavior of the American manatee, Trichechus manatus Linneaus, at Crystal River, Citrus County, Florida. Natl. Geogr, Soc. Res. Rpt., 1968 Projects, pp.157-161.

_____. 1969. Florida's manatees, mermaids in peril. National Geographic Magazine 136(3):342-353.

_____. 1971. Behavior and ecology of the Florida manatee, Trichechus manatus latirostris (Harlan) at Crystal River, Citrus County. Ph.D. Thesis, Cornell University, Ithaca, New York. 285pp.

_____. 1974. Distribution, status and conservation of the manatee in the United States. National Technical Information Service. PB81-140725. Springfield, Virginia. 246pp.

_____. 1976. Manatee in J.N. Layne, ed. Inventory of rare and endangered biota of Florida. Prepared by the Florida committee on rare and endangered plants and animals.

_____. 1979. Ecology and behavior of the manatee (Trichechus manatus) in Florida. Special Publication No. 5, American Society of Mammalogists. 153pp.

Husar, S.L. 1977. The West Indian manatee (Trichechus manatus). U.S. Fish and Wildlife Service, Wildlife Research Report No. 7. 22p.

Irvine, A.B. and H.W. Campbell. 1978. Aerial census of the West Indian Manatee, Trichechus manatus, in the southeastern United States. Journal of Mammalogy 59(3):613-617.

Jones, J., and R. Johnson. 1967. Sirenians. Pages 366-373 in S. Anderson and J. Jones, Jr., eds. Recent mammals of the world: a synopsis of families. Ronald Press, New York.

Moore, J. 1951a. The status of the manatee in the Everglades National Park, with notes on its natural history. Journal of Mammalogy 32(1):22-36.

_____. 1956. Observations of manatees in aggregations. Am. Mus. Novit. 1181:1-24

_____. 1957. Newborn young of a captive manatee. Journal of Mammalogy 38(1):137-138.

Morgan, M.A. and G.W. Patton. 1990. Aerial studies of the West Indian Manatee (Trichechus manatus) on the West Coast of Florida. Mote Marine Laboratory Technical Report #167.

Nabor, P.L. and G.W. Patton. 1989. Aerial studies of the West Indian Manatee (Trichechus manatus) from Anna Maria Florida to Northern Charlotte Harbor including the Myakka River: Recommended Habitat Protection and Manatee Management Strategies. Mote Marine Laboratory Technical Report #134. 94pp.

Odell, D.K. 1982. The West Indian manatee Trichechus manatus Linnaeus. p.828-837, In: J.A. Chapman and G. A. Feldhamer (eds.) Wild Mammals of North America. Johns Hopkins University Press, Baltimore. 1184 p.

O'Shea, T.J. and S.H. Shane. 1985. Female offspring behavior in West Indian manatees. Abstract no. 0470. Session W03. Abstracts of papers and posters. Fourth International Theriological Congress, Edmonton, Canada.

Packard, J.M. 1981. Abundance, distribution, and feeding habits of manatees (Trichechus manatus) wintering between St. Lucie and Palm Beach Inlets, Florida. United States Fish and Wildlife Service Contract Report No. 12-16-004-80-105, 142pp.

Phillips, C. 1964. The captive sea. Chilton Books, Philadelphia. pp 27,171-183.

Rathbun, G.B., R.K. Bonde, and D. Clay. 1982. The status of the West Indian manatee on the Atlantic coast north of Florida. Pages 152-165 in R.R. Odum and J.W. Guthrie (eds.). Proceedings of the Symposium on Nongame and Endangered Wildlife. Georgia Department of Natural Resources, Game and Fish Division, Technical Bulletin WL5. 179pp.

Stejner, L. 1886. On the extermination of the great northern sea-cow (Rhytina). American Geographic Society, Bulletin, 4:317-328.

Weigle, B.L., B.K. Bond, S.J. Marcus and P.A. Carboara. 1987. Coordinated manatee aerial survey on the east coast of Florida during 1986. Abstract of the Seventh Biennial Conference of the Biology of Marine Mammals. Miami, Florida, Dec. 5-9, 1987.

Walker, E. 1964. Mammals of the world. John Hopkins Press, Baltimore. 3 vols. 1500pp.

Williams, P. 1988. Our Silent Sirens. New Zoo News 3(4). p.8.

TABLE 1. 1988 FLIGHT PARAMETERS.

FLIGHT	DATE	BEGIN	FINISH	MANATEE COUNTS	PRIMARY OBSERVER	SECONDARY OBSERVER	PILOT	WATER CLARITY	SURFACE	COMMENTS
A	N: 1/15	913	1453	0	J.S.	--	P.G.	F-E	1-2	
	S: 1/16	839	1243	4	J.S.	PAUL D.	P.G.	P-G	1-2	
B	N: 2/22	915	1327	0	J.S.	--	P.G.			
	S: 2/18	900	1346	5	J.S.	--	P.G.	F-G	1	
C	N: 3/31	806		15	J.S.	S.S.	P.G.	P-G	1-2	DOUBLE SURVEY
	S: 3/31		1425	39	J.S.					
D	N: 4/27	4.8	HOURS	19	P.N.	J.P.	S.S.	F-G	0-1	BREAK: DETERIORATING CONDITIONS ABORT SECTOR VII: AIR TRAFFIC.
	S: 4/29	915	1505	80	P.N.	O.S.	S.S.	F-G	1	RESUME MID-SECTOR VII. SBNS.
E	N: 5/10	850	1359	6	P.N.	O.S.	S.S.	G-E	0-1	
	S: 5/11	855	1315	58	P.N.	--	S.S.	F-G	0-1	SBNS.
F	N: 5/23	843	1417	21	J.P.	--	S.S.	F-E	0-3	
	S: 5/26	852	1528	48	P.N.	--	S.S.	F-G	0-2	SBNS.
G	N: 6/02	848	1335	9	P.N.	--	S.S.	F-E	0-2	
	S: 6/03	853	1454	75	P.N.	--	S.S.	F-G	0-1	SBNS.
H	N: 6/16	839	1412	10	P.N.	--	S.S.	P-G	1	
	S: 6/17	816	1221	65	P.N.	--	S.S.	F-G	0-1	SBNS.
I	N: 6/27	901	1440	11	P.N.	--	S.S.	B-G	1	SECTORS I-III BEACH NOT SURVEYED.
	S: 6/28	906	1428	31	P.N.	--	S.S.	P-G	0-2	SBNS.
J	N: 7/11	903	1347	8	P.N.	--	S.S.	F-G	1	
	S: 7/13	859	1257	54	P.N.	--	S.S.	P-F	1-3	SBNS.
K	N: 7/25	858	1318	10	P.N.	--	S.S.	F-E	0-2	
	S: 7/26	859	1408	76	P.N.	--	S.S.	F-G	0-1	SBNS. BEGIN SEC. XII, FLEW N: S.T.S
L	N: 8/11	836	1234	13	P.N.	--	B.F.	P-F	1-2	ABORT SECTOR V: S.T.S.
	S: 8/17	854	1500	25	P.N.	--	S.S.	P	1-3	SBNS. RESUME SEC V-ABORT SEC XII:STS
M	N: 8/25	917	1506	16	J.P./P.N.	--	S.S.	F-G	1-2	NEW OBSERVER: ILLNESS. NO S. SURVEY.
N	S: 9/01	905	1439	33	P.N.	--	S.S.	P-G	1-3	SBNS. RIVER LEVEL HIGH SEC XII.
	N: 9/20	910	1604	36	J.P./P.N.	P.N./--	S.S.	F-G	1-2	CHANGED OBSERVERS AT BREAK.
O	S: 9/27	938	1512	75	P.N.	T.B.	S.S.	P-F	1-2	SBNS.
	N: 9/28	914	1621	28	P.N.	K.K.	S.S.	P-E	1-2	DROP OFF PASSENGER: ILLNESS.
P	S: 10/4	906	1508	78	P.N.	--	S.S.	P-F	1-3	SBNS.
Q	N:10/11	912	1500	49	P.N.	--	S.S.	P-G	1-3	
	S:10/12	919	1605	64	P.N.	--	S.S.	P-G	0-2	
R	N:10/24	920	1507	38	P.N.	G.H.	S.S.	F-G	1-2	
	S:10/25	911	1535	71	P.N.	--	S.S.	P-G	1-2	COLD FRONT IN MORNING.
S	N:11/17	922	1342	41	P.N.	--	S.S.	G-E	0-1	NO S. SURVEY DUE TO S.T.S.& COLD.
T	N:12/06	844	1312	14	P.N.	--	S.S.	F-E	1-2	
	S:12/07	1024	1456	33	P.N.	--	S.S.	P-E	0-3	DELAY:FOG. LOWER X11 NOT SURVEYED.
U	N:12/20	842	1408	5	P.N.	--	B.F.	G-E	1	
	S:12/21	911	1344	17	P.N.	--	S.S.	G-E	0-1	

KEY:
SBNS=SOUTHERN BEACHES NOT SURVEYED.
S.T.S.=SERVERE TROPICAL STORMS.
SEE ACKNOWLEDGEMENTS FOR LIST OF PARTICIPANTS (OBSERVERS AND PILOTS).

Table 2a. Water Clarity Scale.

Scale	Visibility Through Water
EXCELLENT =	Greater than 3M.
GOOD =	2-3M.
FAIR =	3/4-2M.
POOR =	1/4-3/4M.
BAD =	Less than 1/4M.

Table 2b. Surface Conditions Scale.

Scale	Effects Observed at Sea
0	Sea-like mirror.
1	Ripples with appearance of scales.
2	Small wavelets; crests begin to break; scattered whitecaps,
3	Large wavelets; crests begin to break; scattered whitecaps.
4	Moderate waves, taking a longer form; many whitecaps; some spray.

(Adapted from the Beaufort Scale, which is not suited for nearshore use).

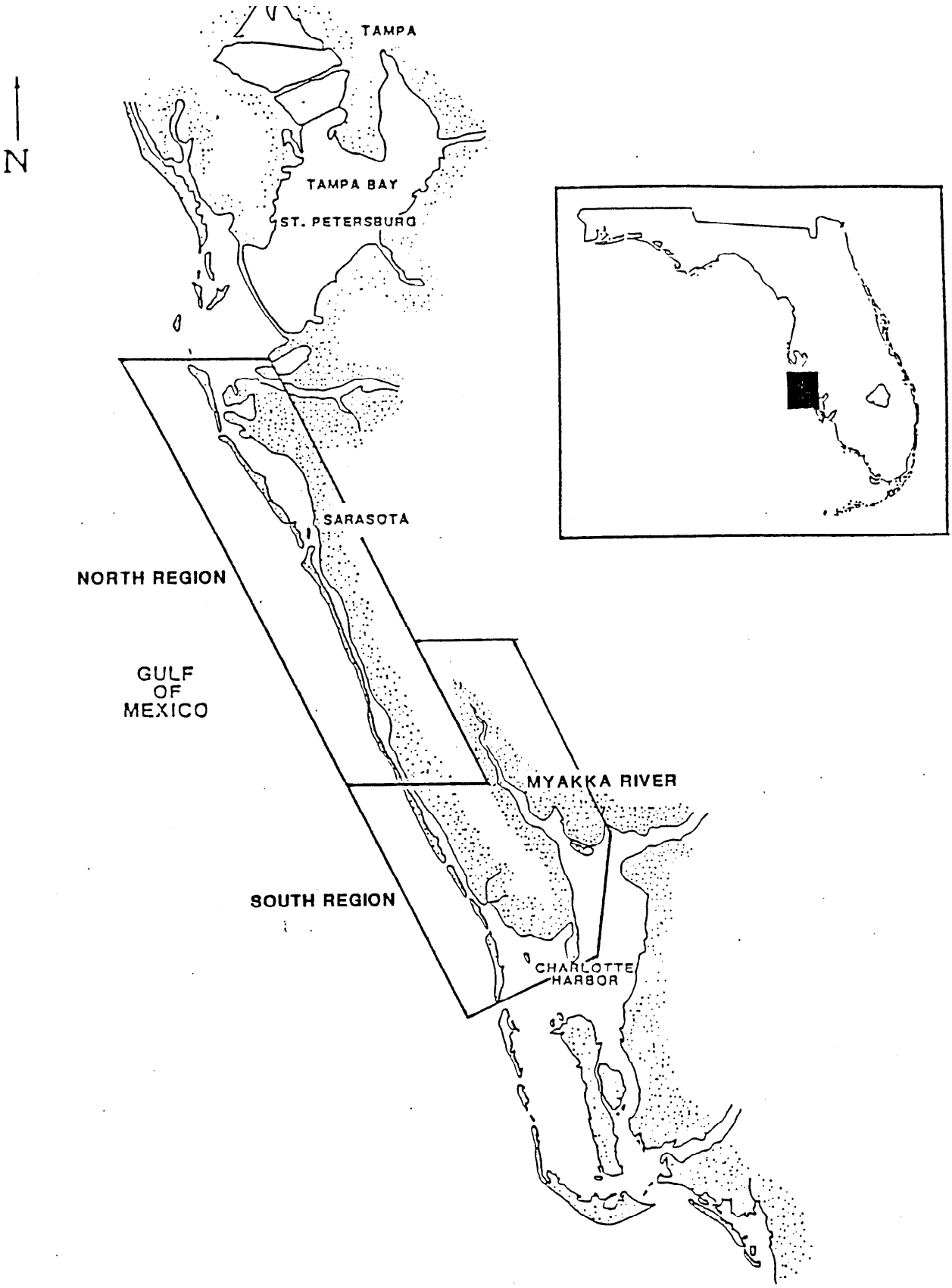


Figure 1. **Location of the Study Area, Showing Division into North and South Regions.**

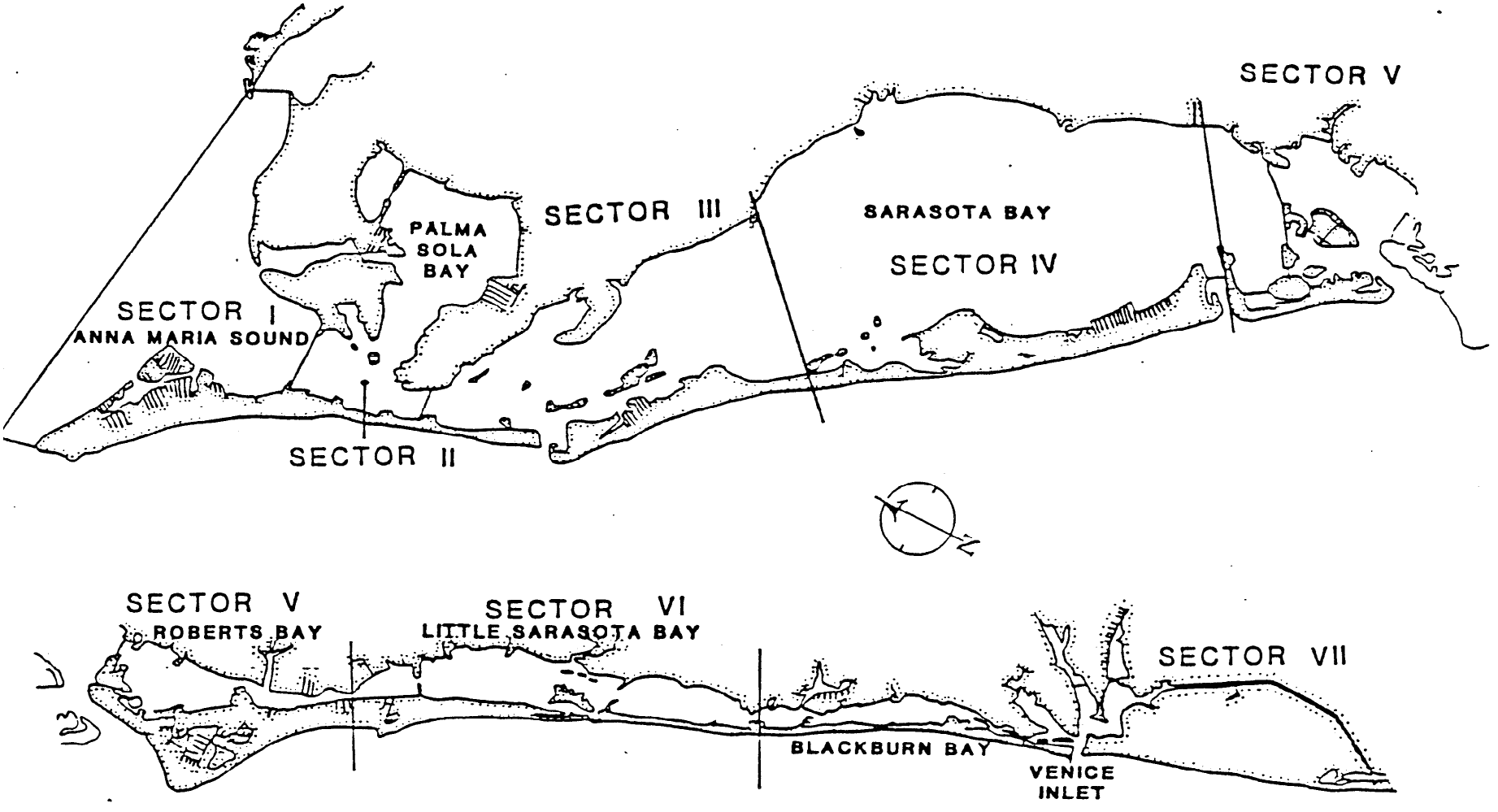


Figure 2a. Division of the survey area into twelve sectors.

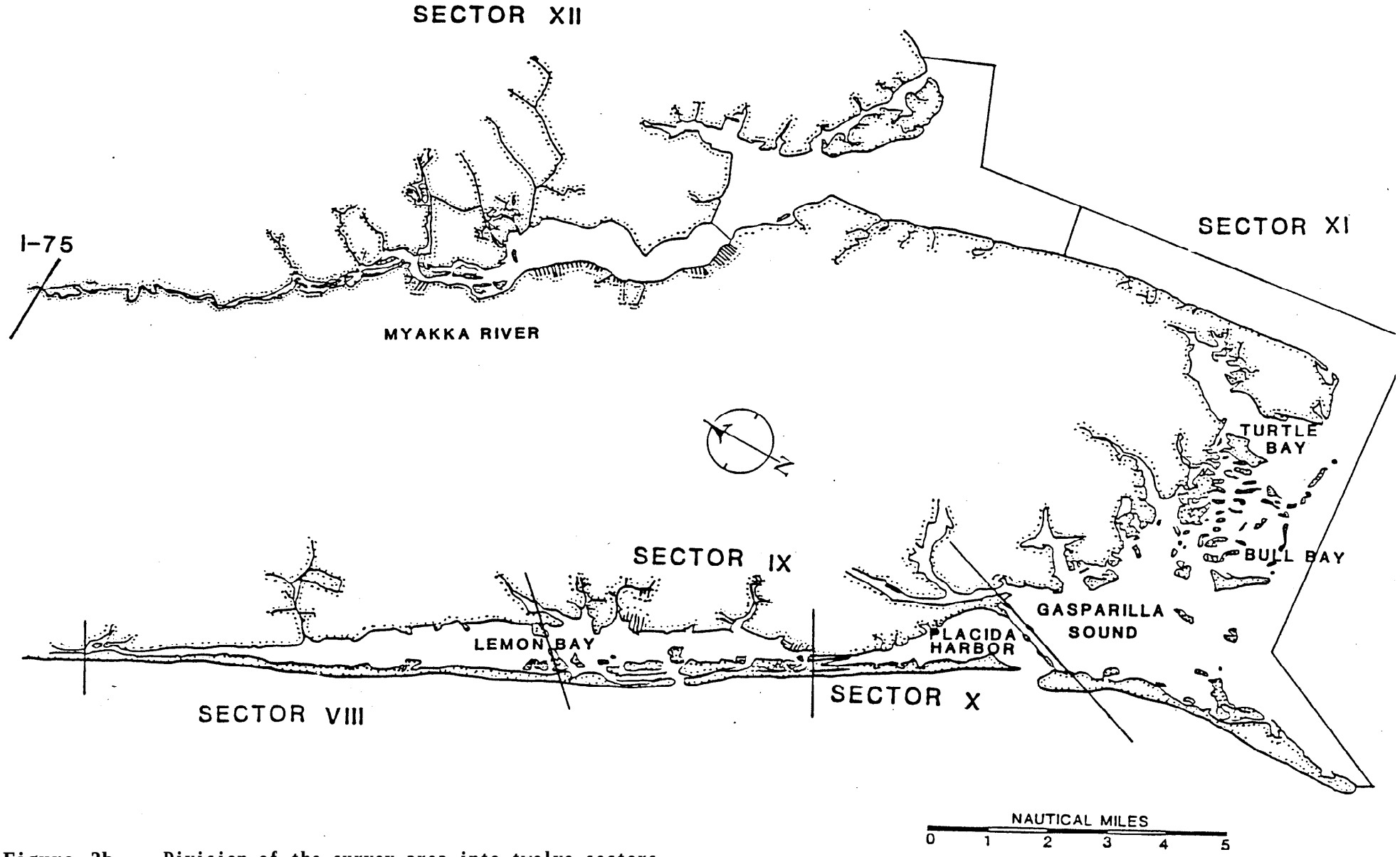


Figure 2b. Division of the survey area into twelve sectors,

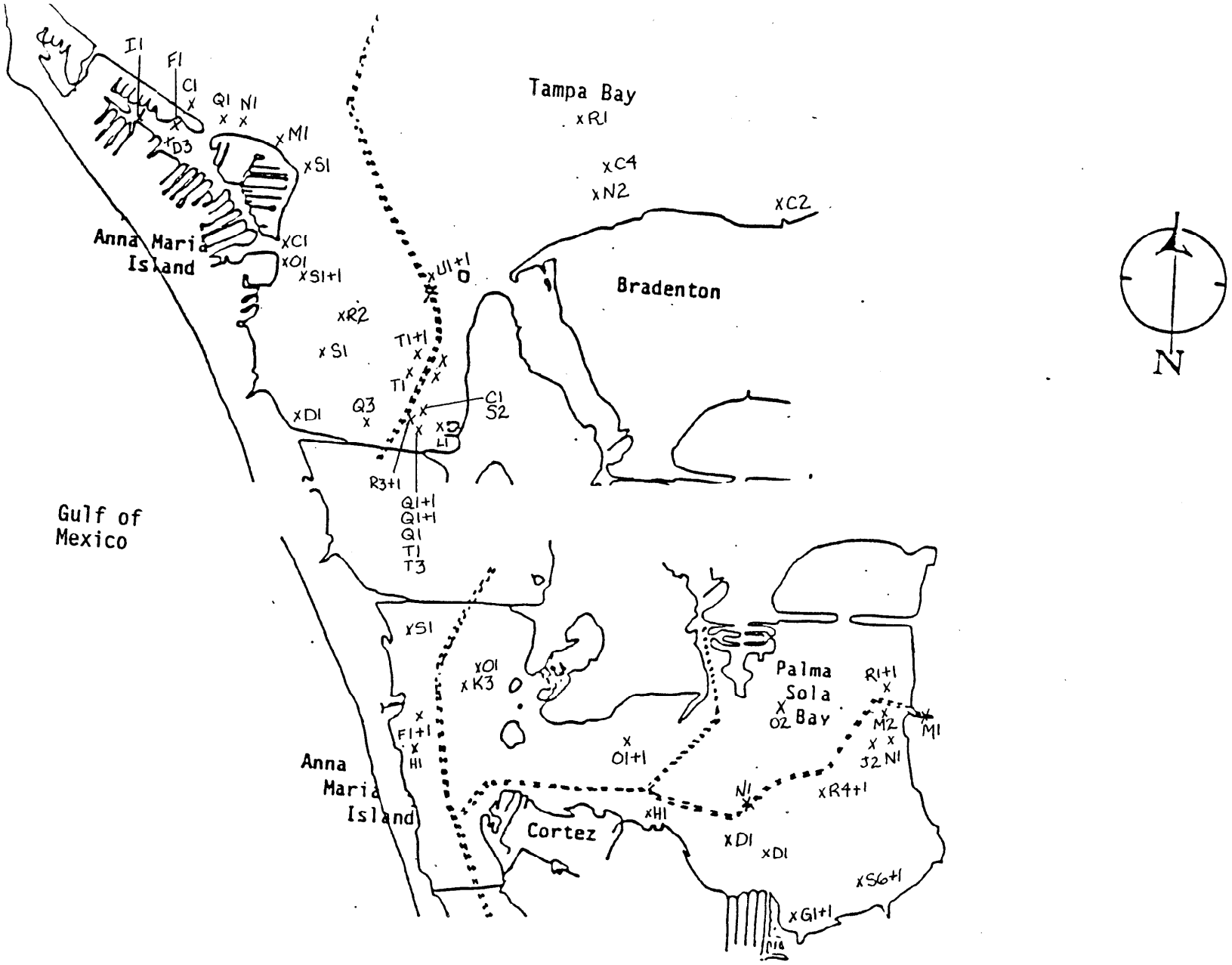


Figure 3a. Manatee Sighting Locations, 1988: Mouth of Manatee River and Anna Maria Sound.

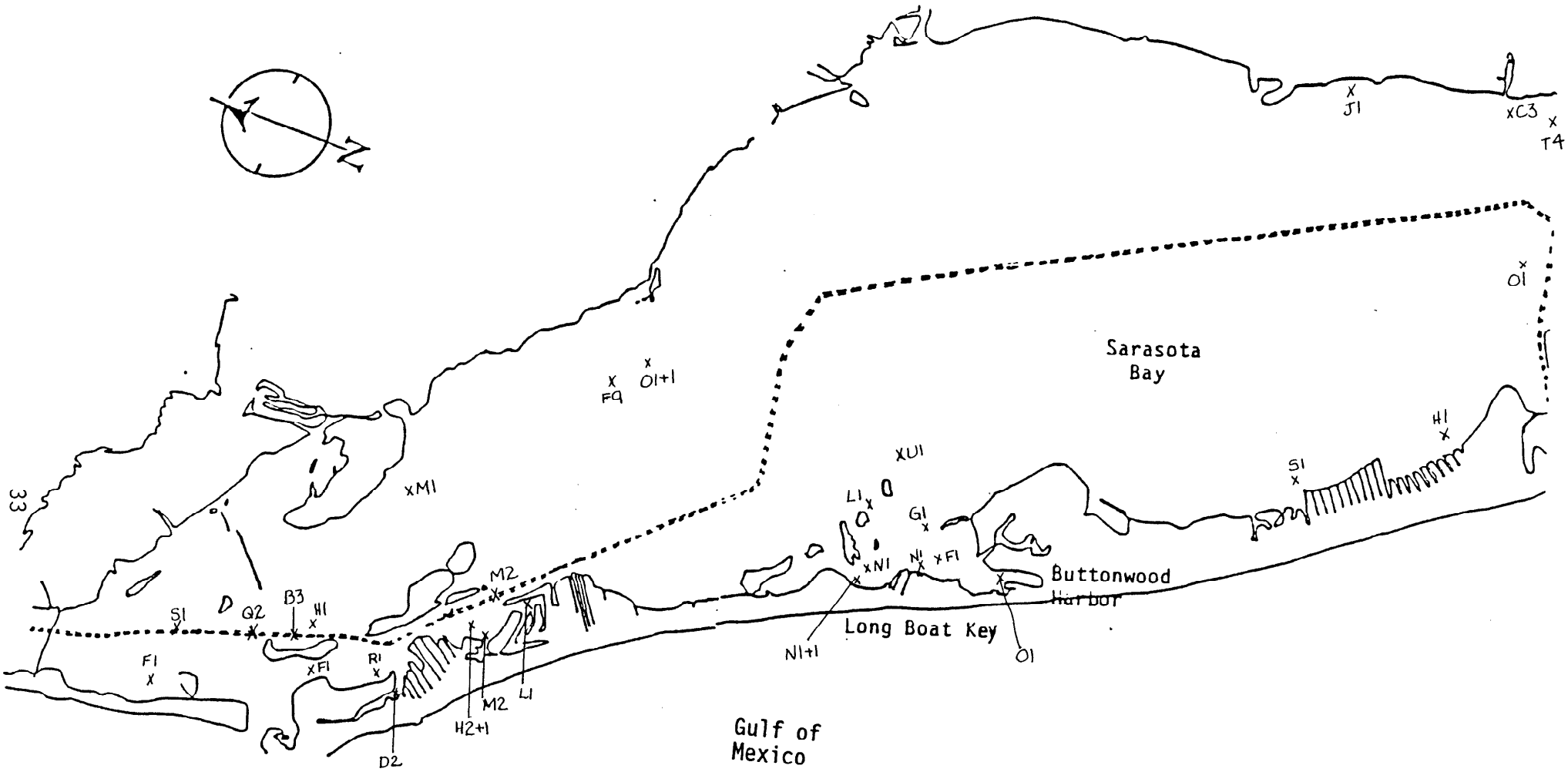


Figure 3b. **Manatee Sighting Locations, 1988: Sarasota Bay.**

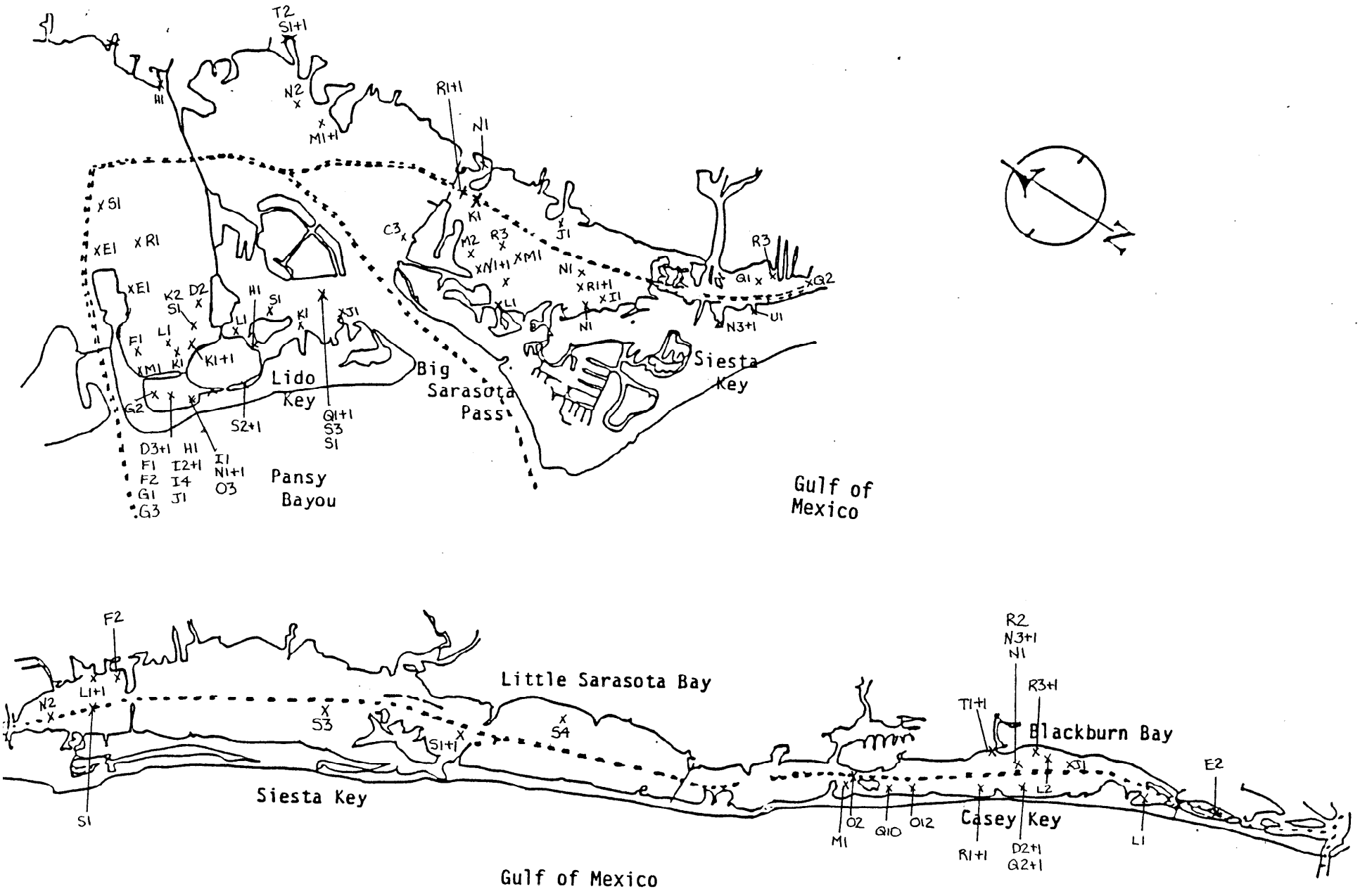
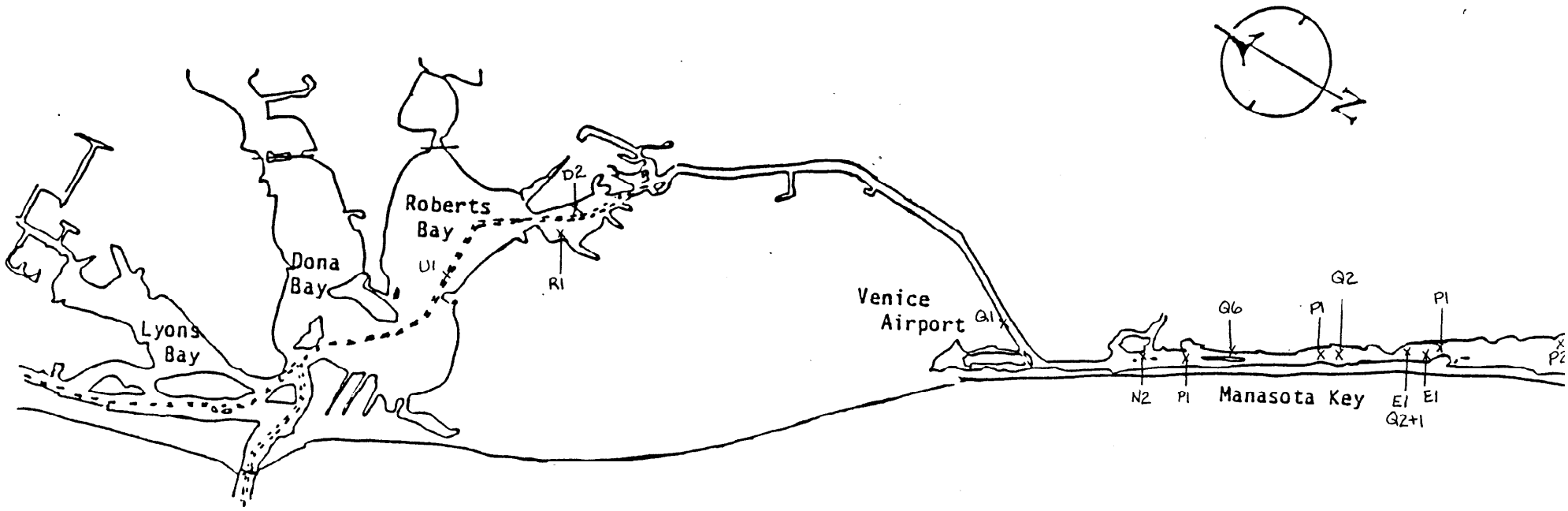


Figure 3c. Manatee Sighting Locations; 1988:
Sarasota area, Little Sarasota Bay, and Blackburn Bay.



Gulf of Mexico

Figure 3d. **Manatee Sighting Locations: 1988: Venice Area.**

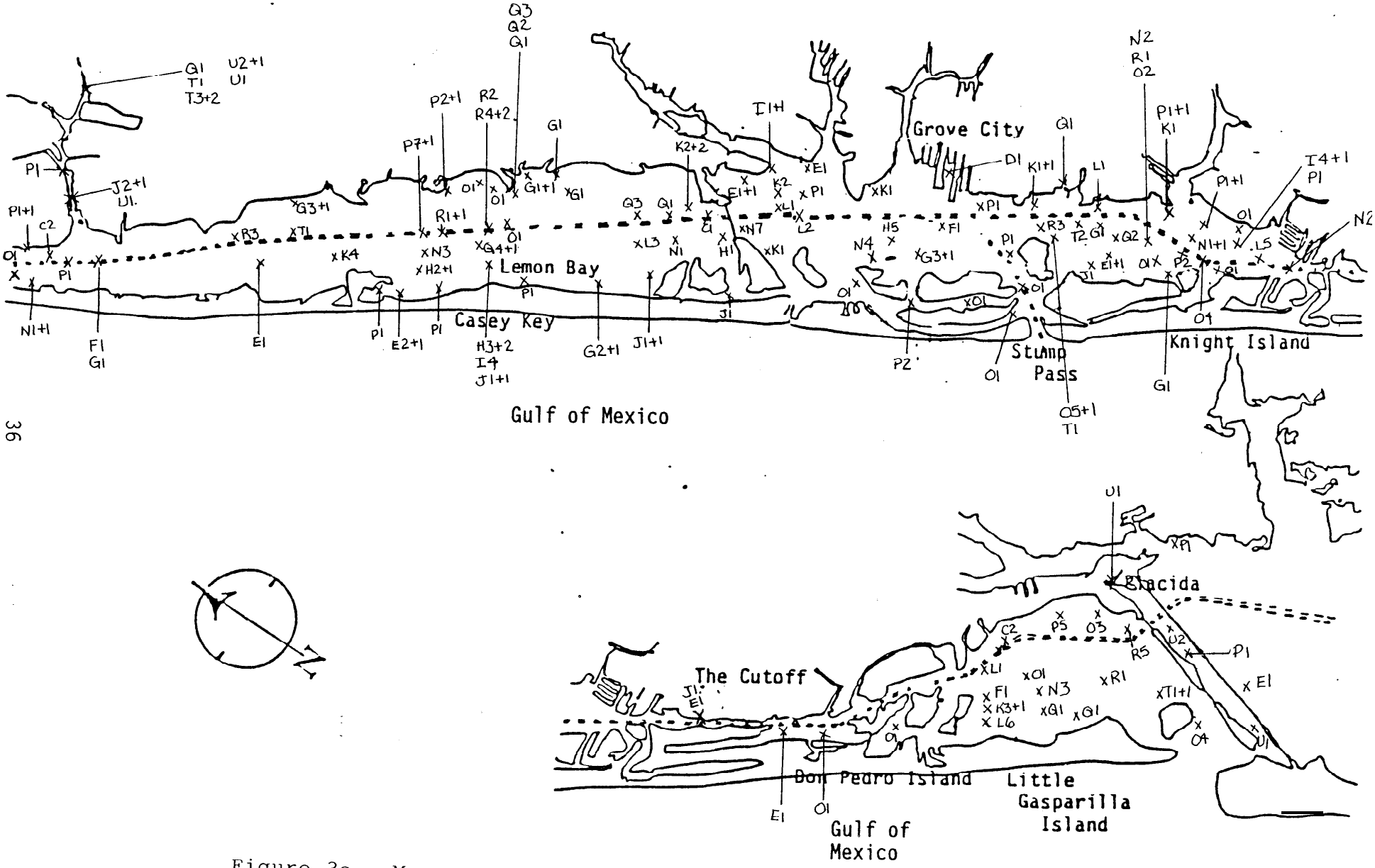


Figure 3e. Manatee Sighting Locations, 1988: Lemon Bay and Placida Harbor.

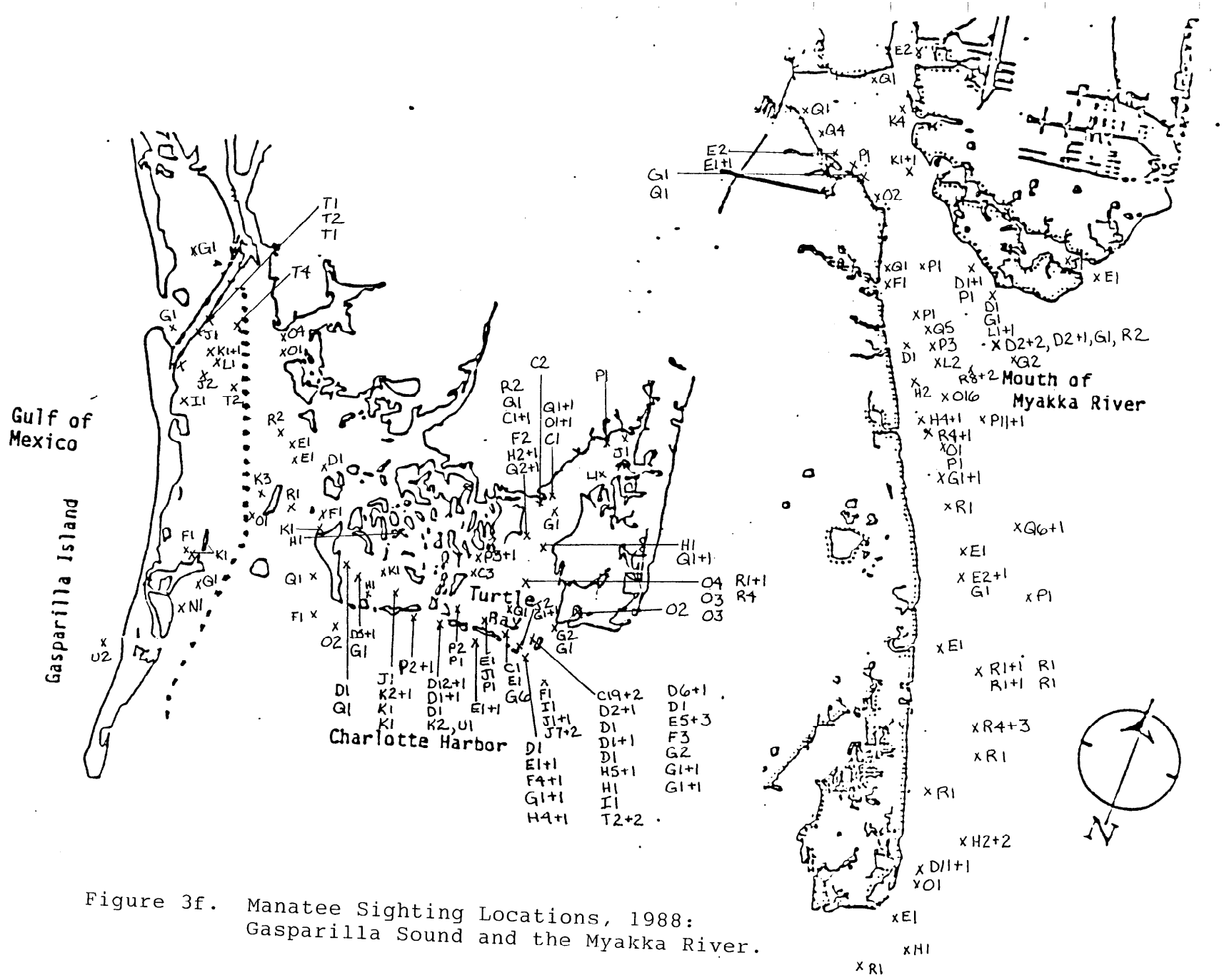


Figure 3f. Manatee Sighting Locations, 1988: Gasparilla Sound and the Myakka River.

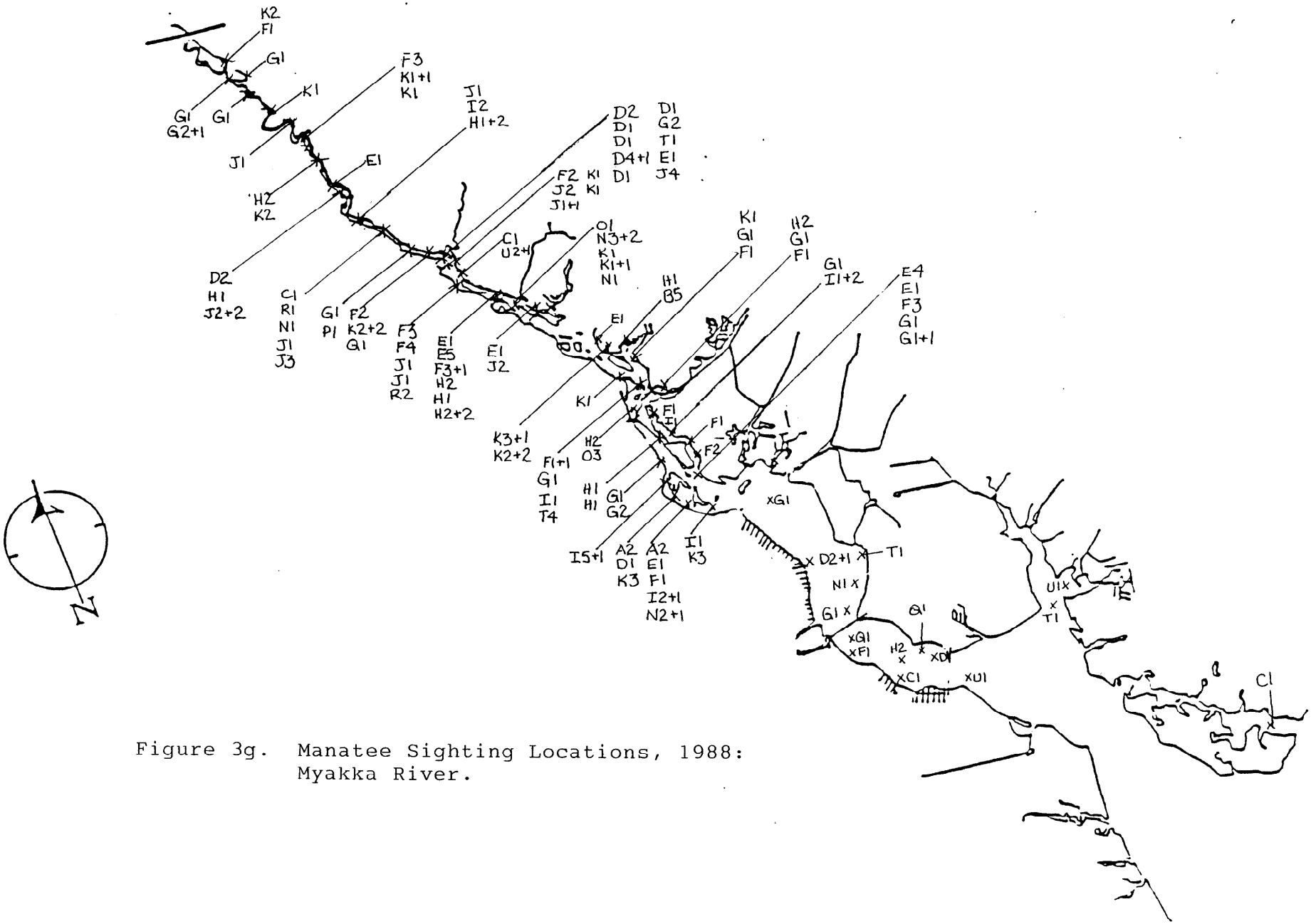


Figure 3g. Manatee Sighting Locations, 1988: Myakka River.

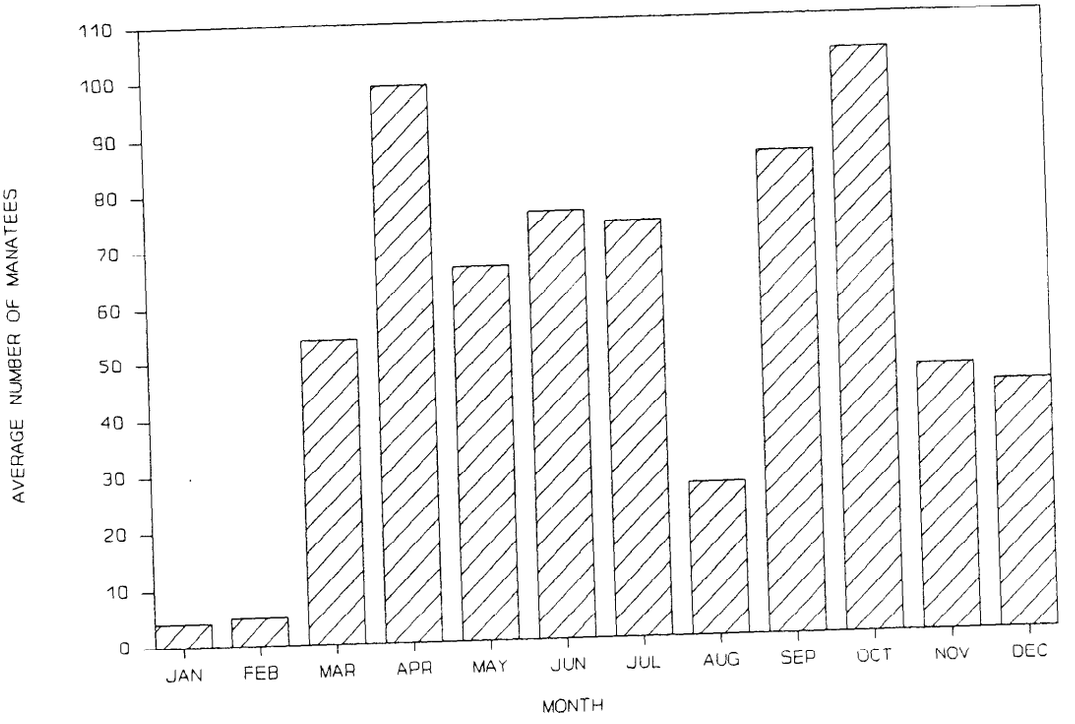


Figure 4. Average number of manatees sighted in each month for the entire survey area, 1988.

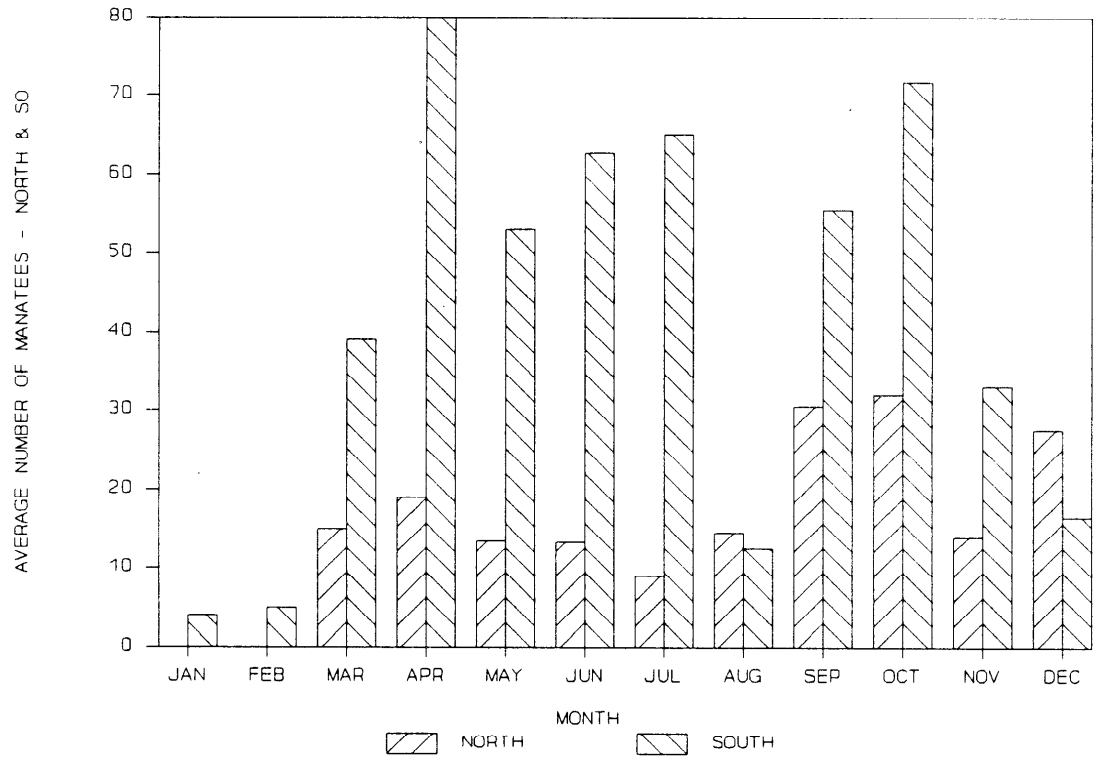


Figure 5. Average number of manatees sighted in each month for the northern and southern survey areas, 1988.

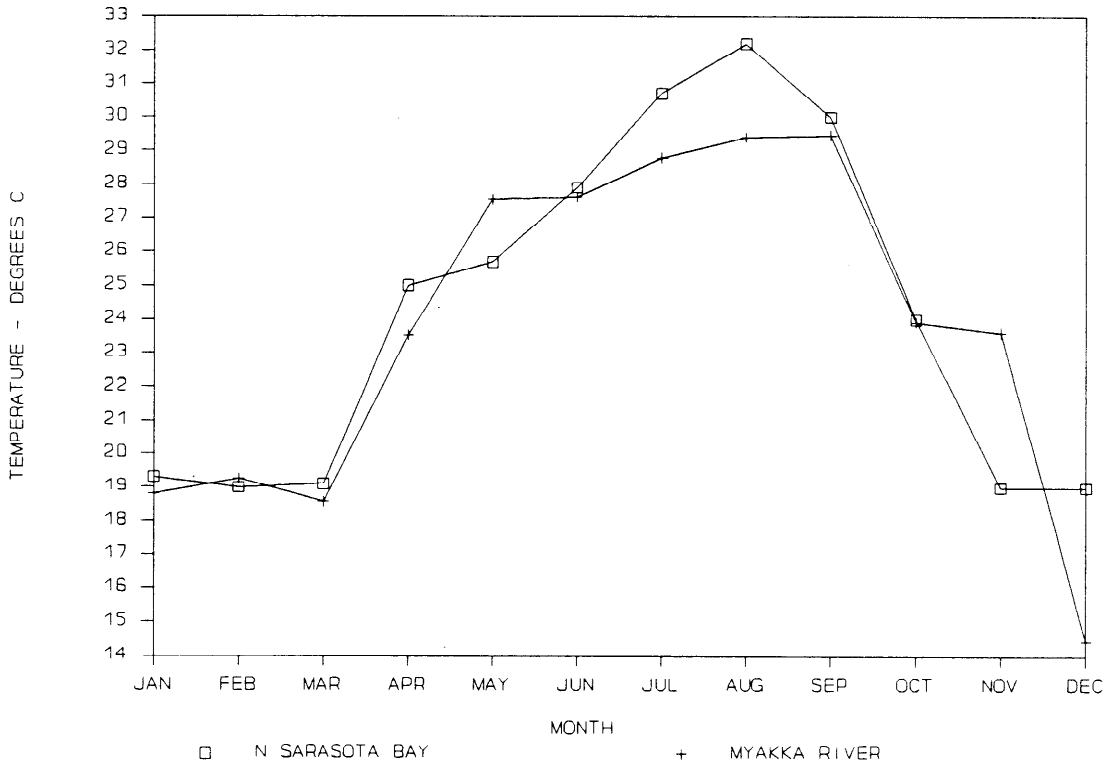


Figure 6. Water temperatures for northern Sarasota Bay and Myakka River, 1988.

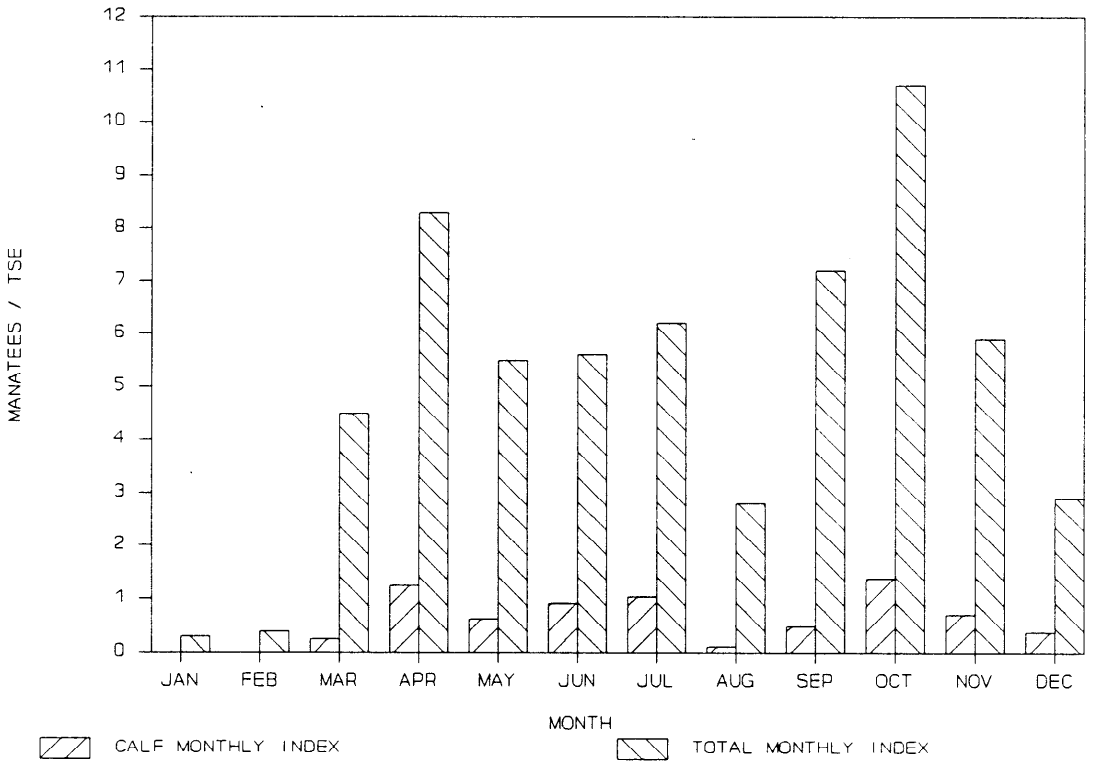


Figure 7. Monthly index of total sightings and calf sightings as number per survey effort for each month, 1988.

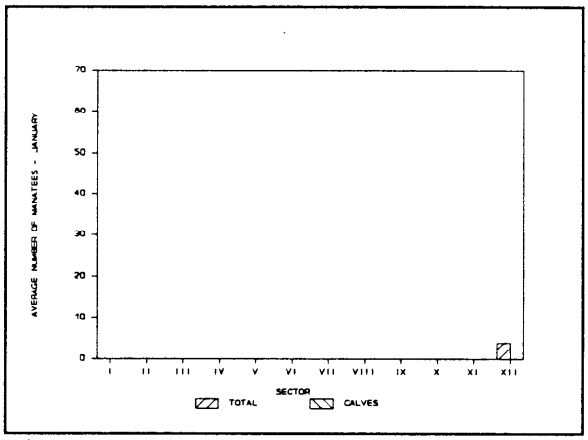


Figure 8a. Number of manatees in each sector, January, 1988.

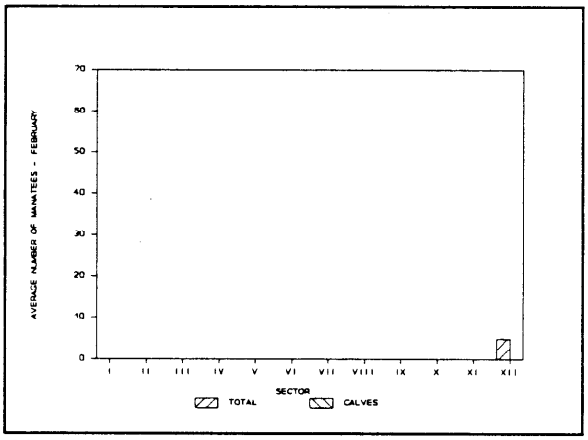


Figure 8b. Number of manatees in each sector, February, 1988.

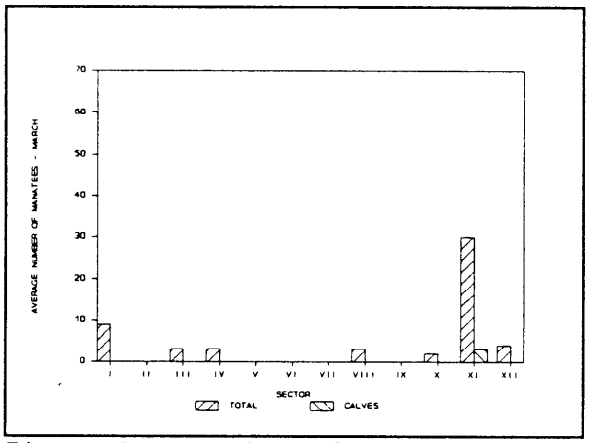


Figure 8c. Number of manatees in each sector, March, 1988.

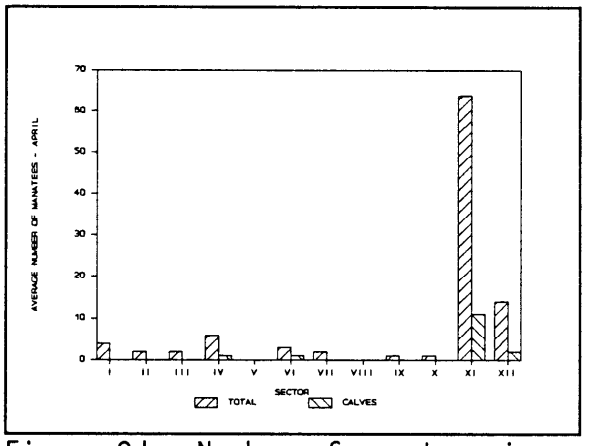


Figure 8d. Number of manatees in each sector, April, 1988.

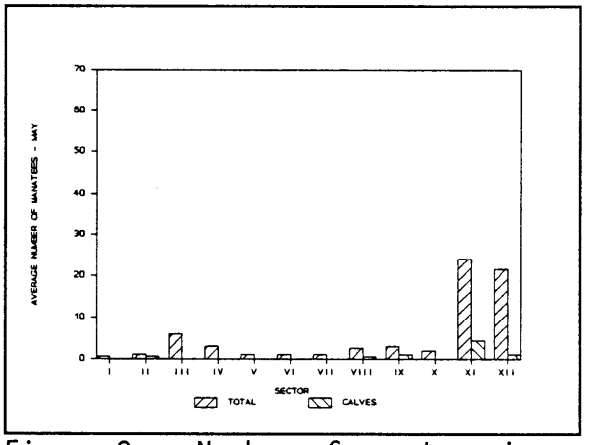


Figure 8e. Number of manatees in each sector, May, 1988.

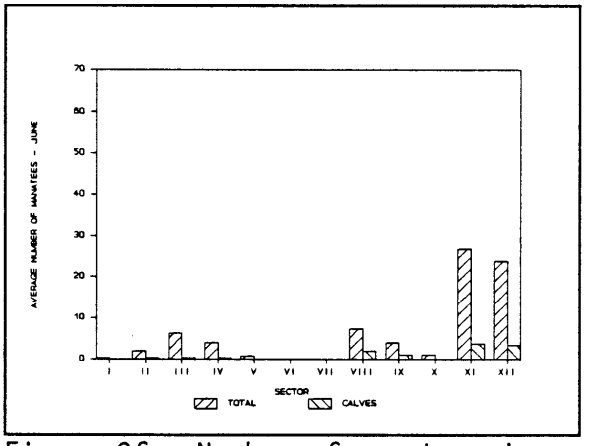


Figure 8f. Number of manatees in each sector, June, 1988.

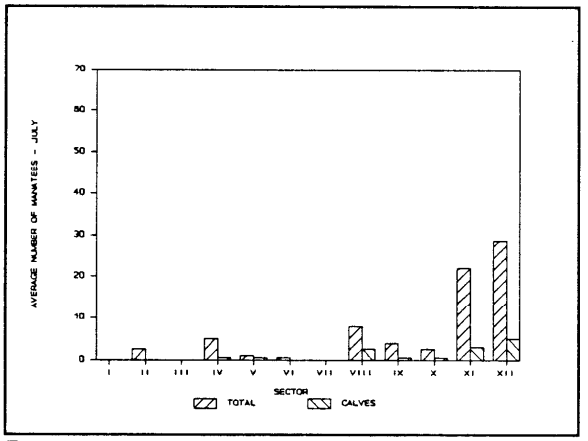


Figure 8g. Number of manatees in each sector, July, 1988.

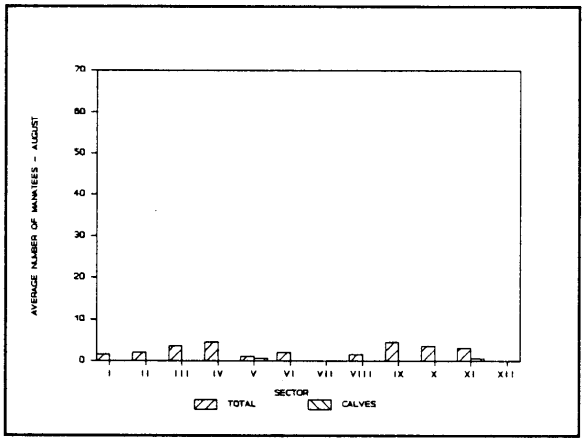


Figure 8h. Number of manatees in each sector, August, 1988.

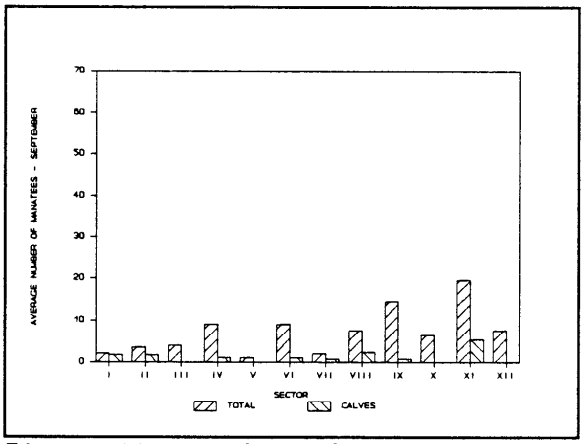


Figure 8i. Number of manatees in each sector, September, 1988.

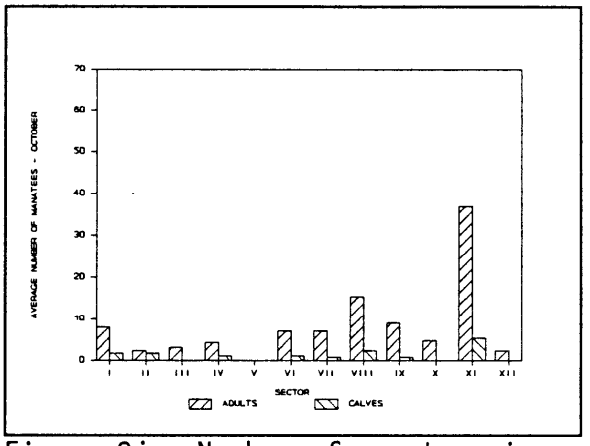


Figure 8j. Number of manatees in each sector, October, 1988.

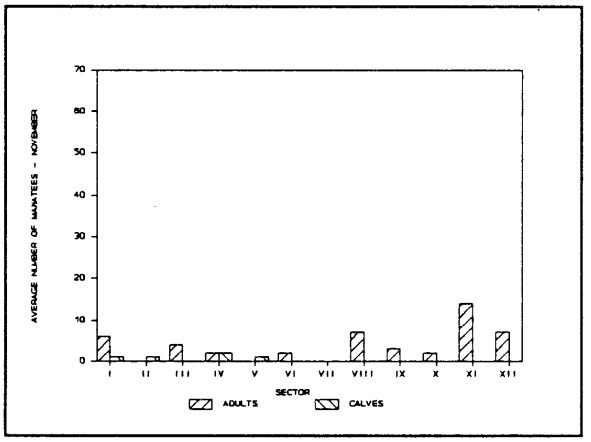


Figure 8k. Number of manatees in each sector, November, 1988.

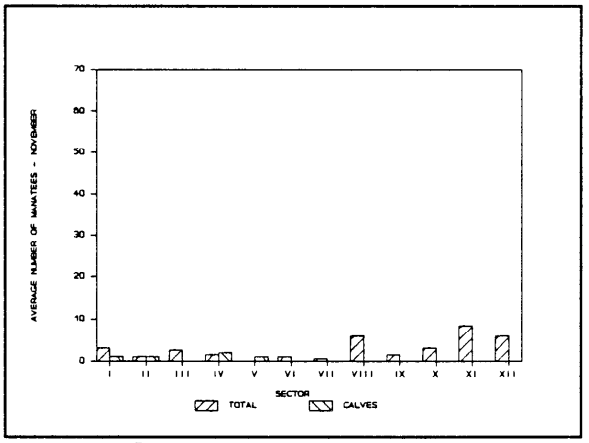


Figure 8l. Number of manatees in each sector, December, 1988.

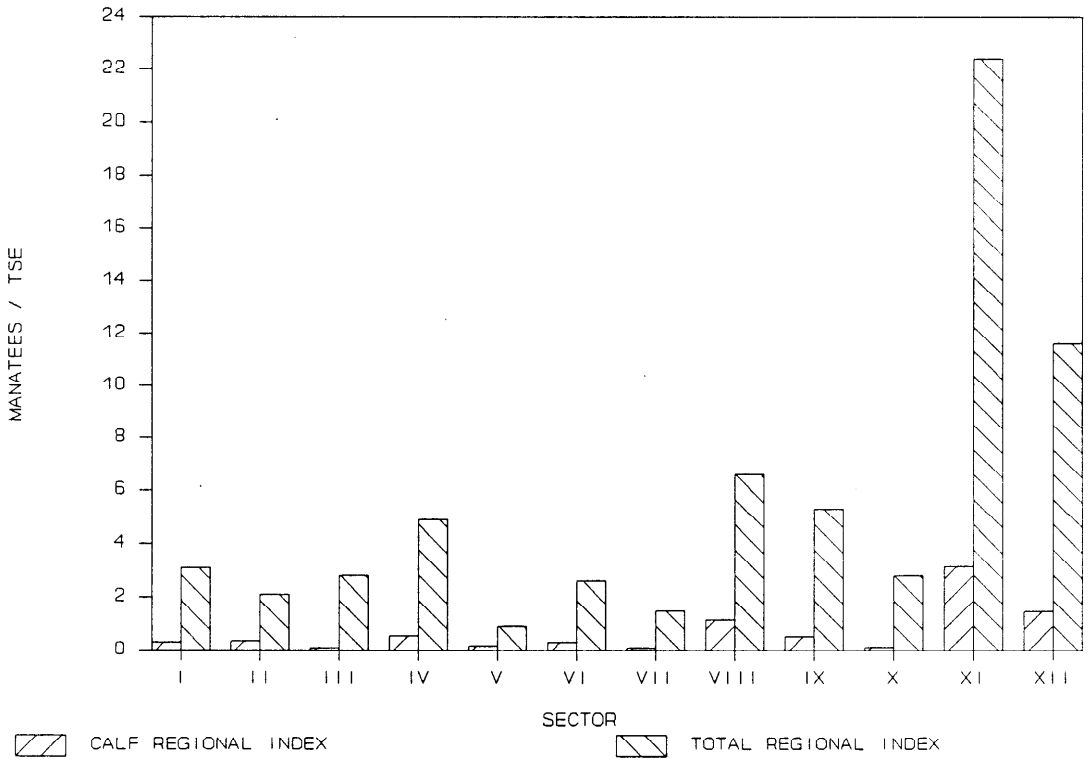


Figure 9. Regional index of total sightings and calf sightings as number per survey effort for each region, 1988.

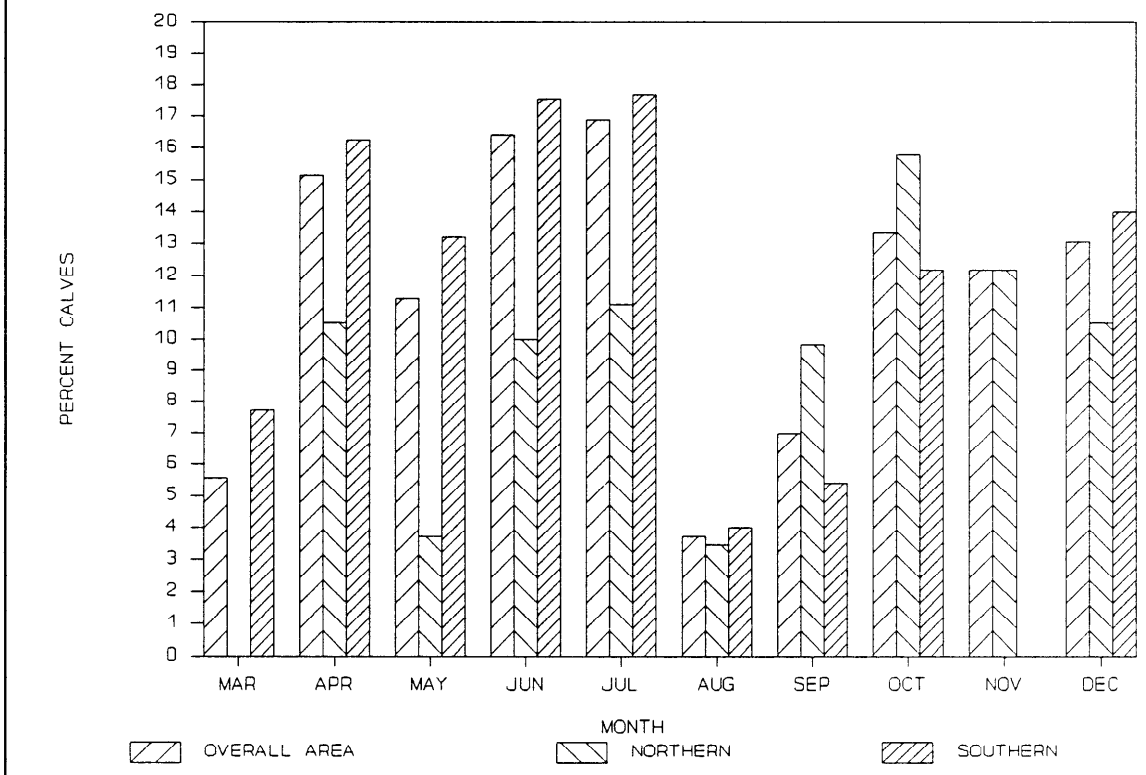


Figure 10. Calf percentages per month for the northern, southern, and total survey areas, 1988.

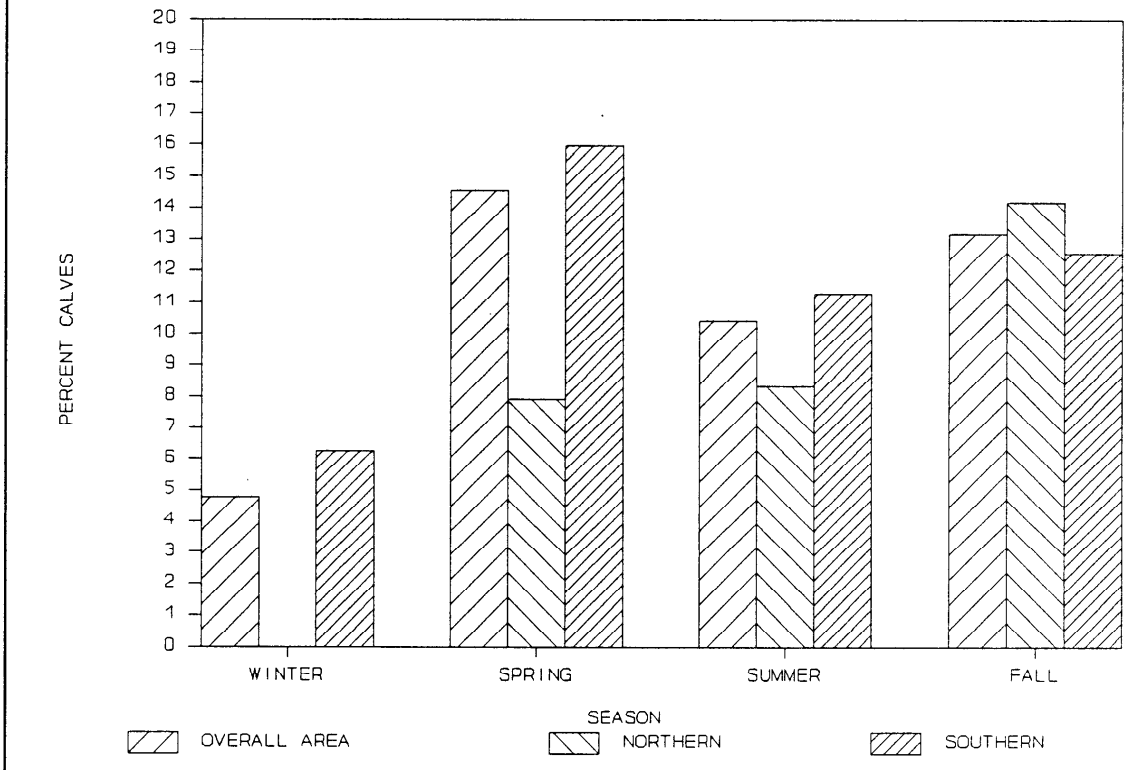


Figure 11. Calf percentages per season for the northern, southern, and total survey areas, 1988.

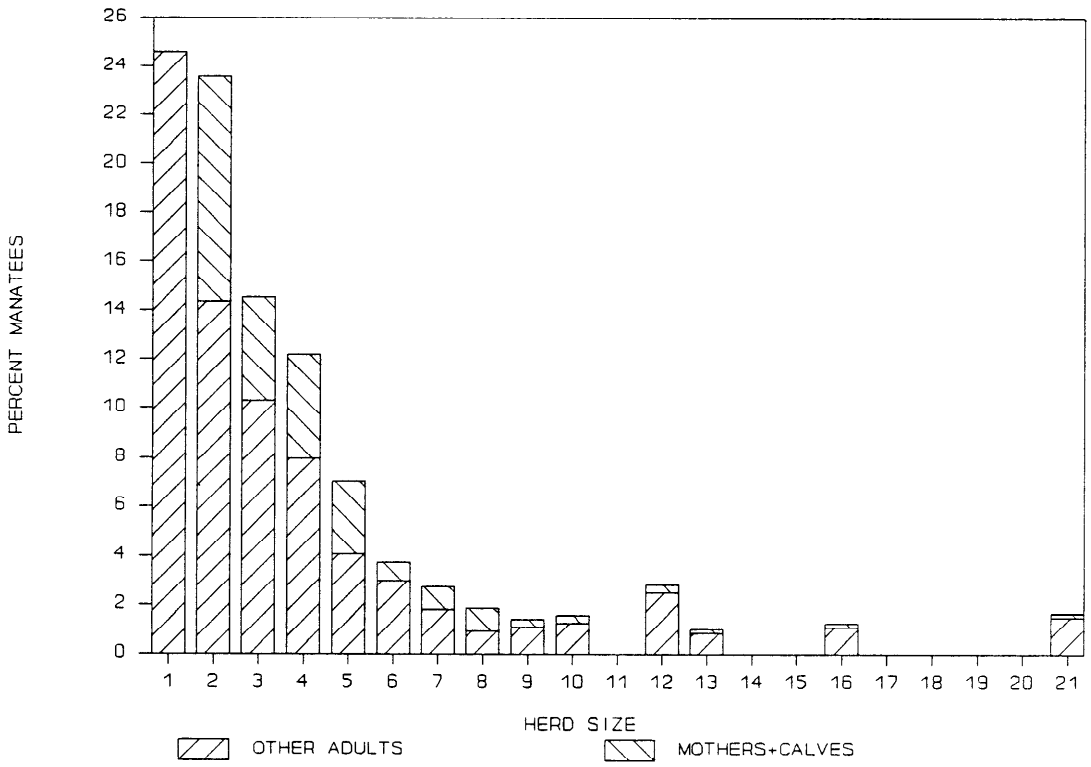


Figure 12. Herd size distribution as percent of total herds, indicating mother-calf pairs, 1988.

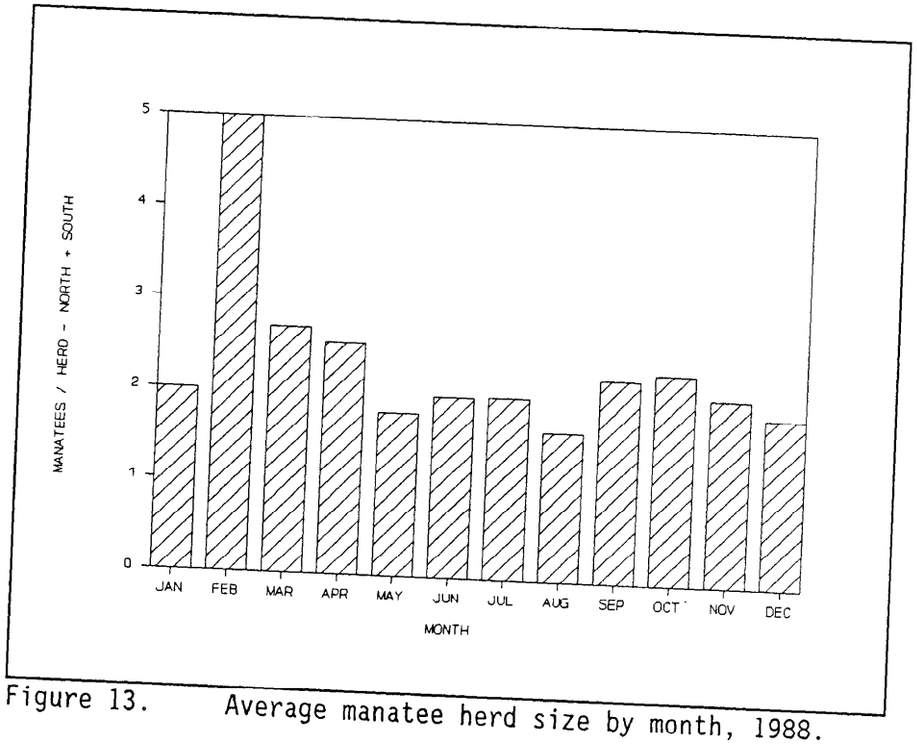


Figure 13. Average manatee herd size by month, 1988.

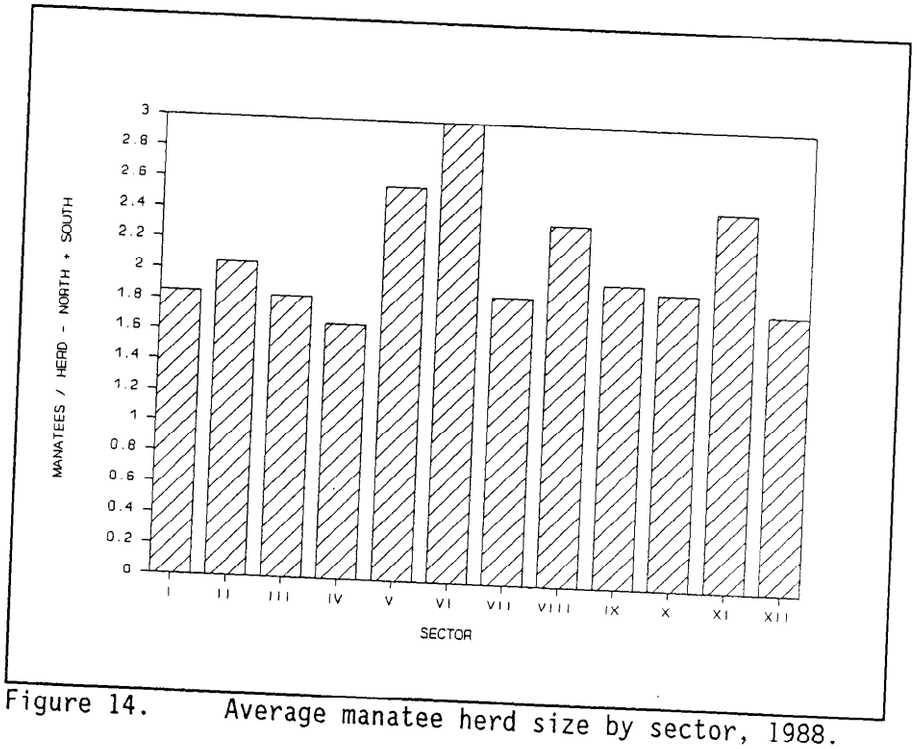


Figure 14. Average manatee herd size by sector, 1988.

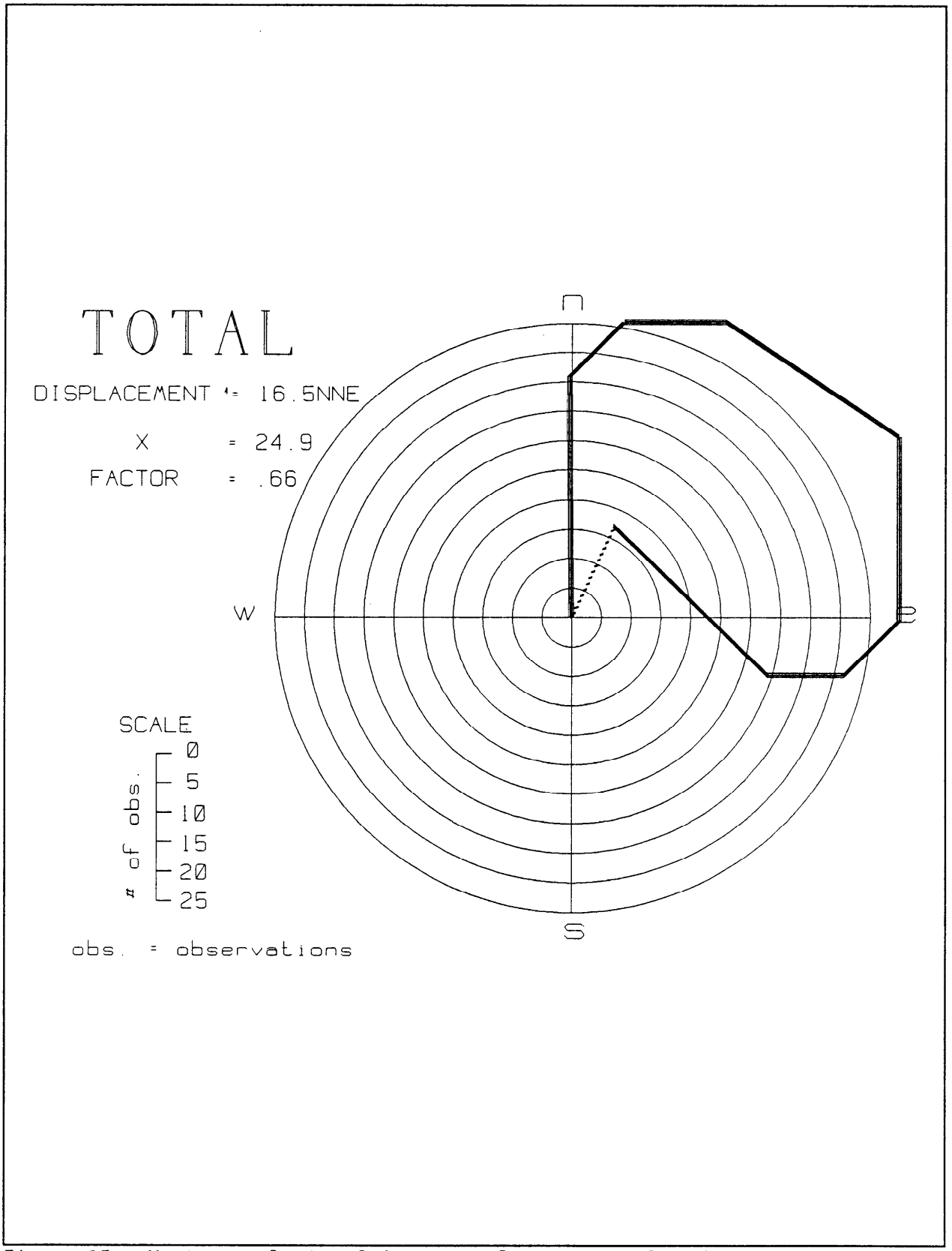


Figure 15. Vector analysis of directional movements for the year, 1988.

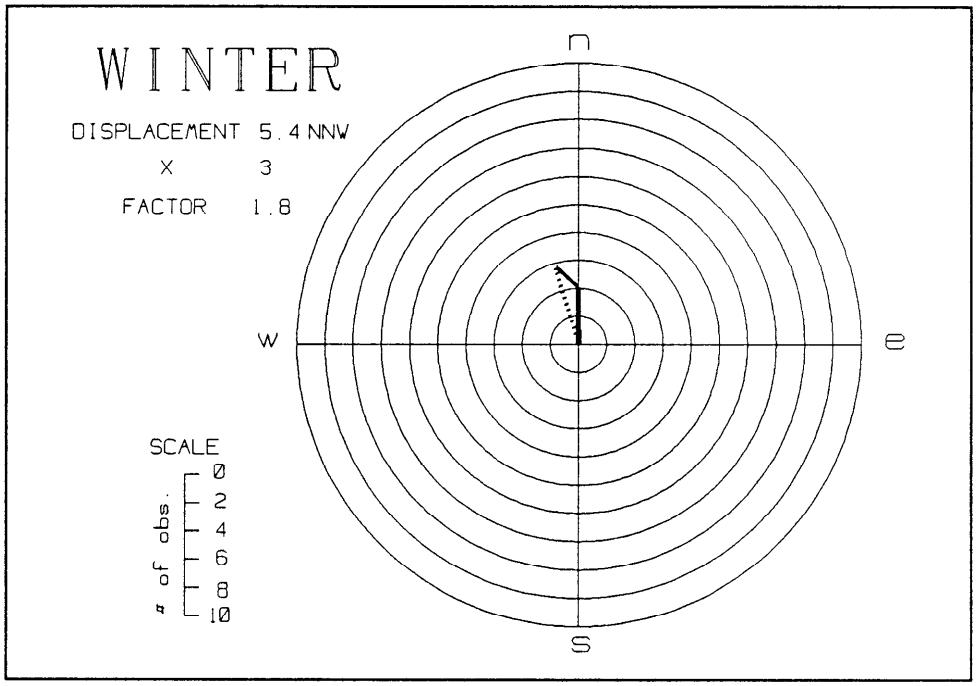


Figure 16a. Vector analysis of directional movements for Winter, 1988.

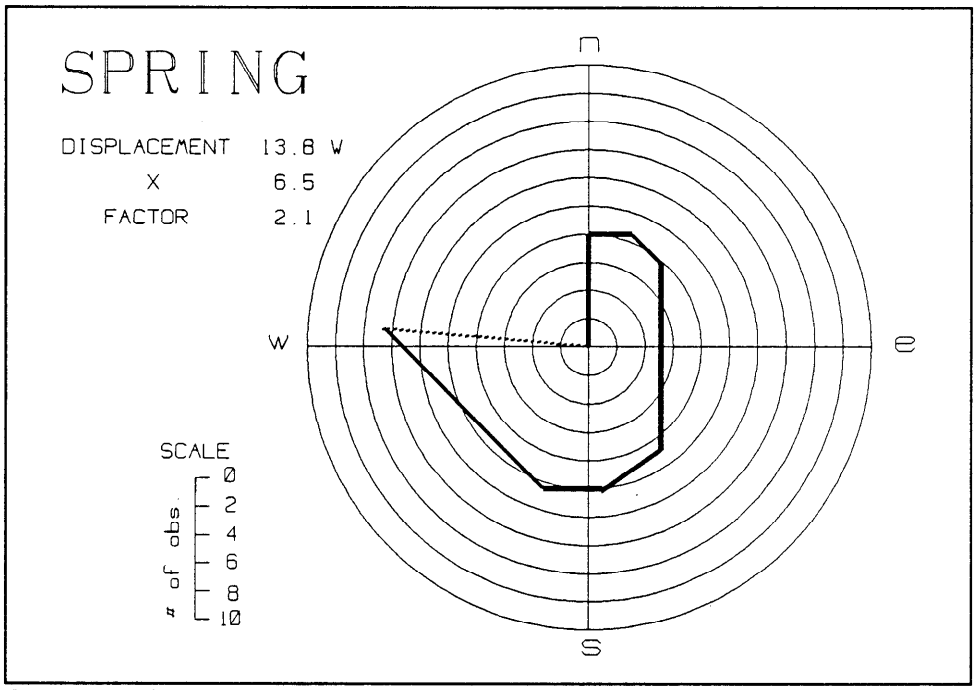


Figure 16b. Vector analysis of directional movements for Spring, 1988.

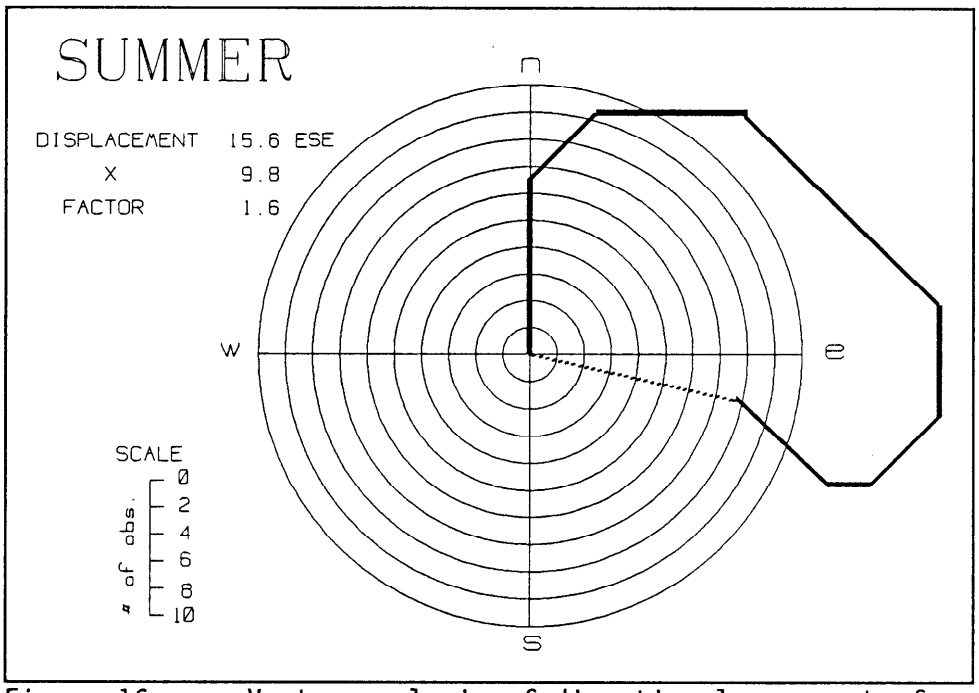


Figure 16c. Vector analysis of directional movements for Summer, 1988.

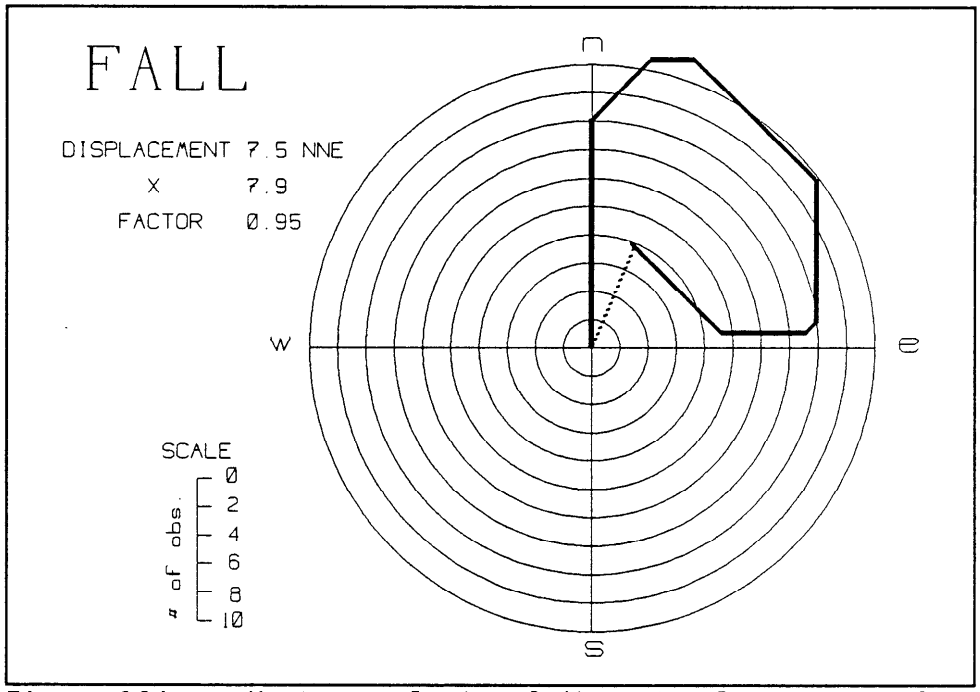


Figure 16d. Vector analysis of directional movements for Fall, 1988.

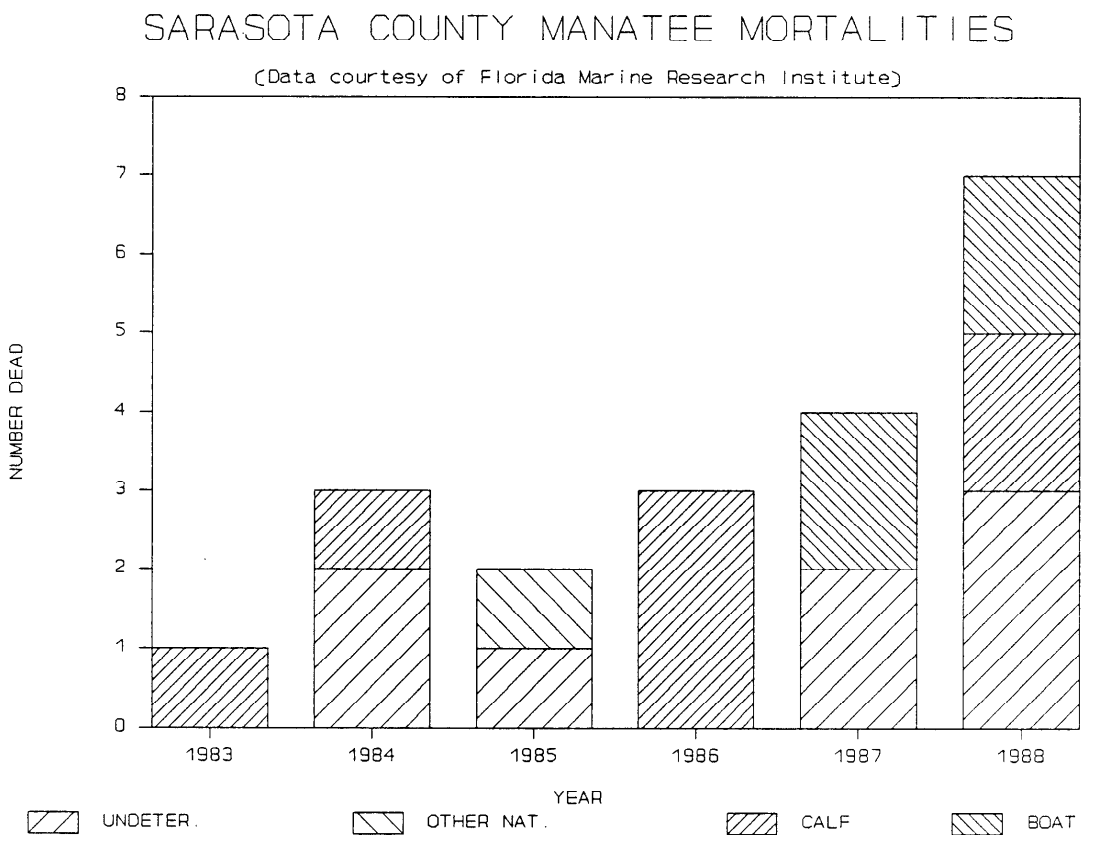


Figure 17. Manatee mortalities for Sarasota County for 1983-1988.